AN ATLAS OF OPHTHALMOSCOPY

by

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Preface.

WHEN arranging for the issue of a new English Edition of Haab's Atlas of Ophthalmoscopy, the British Optical Association were offered full rights of re-publication, subject to a new English translation being made. This offer has been taken full advantage of, because the work is recognised generally as being a Text Book of the highest educational value, which had become almost impossible to obtain, even in the form of second-hand copies. Whilst undertaking the retranslation, it is to be confessed that some little freedom has been taken with the original text; in fact, a somewhat "free translation" has been aimed at, so that, possibly, it can be more easily followed by the student. In no way, however, has the intention of the author been interfered with in any way, either by the addition of matter which was not his own, or the deletion of some of his original work—with the exception of an addition of certain matter which is explanatory of the more recent developments in ophthalmoscopy, in the use of self-luminous instruments and red free screens. It is hoped that by so doing, the volume will become an even more useful guide to the student and of increased value to those who are already acquainted with its advantages. The Plates have been printed for us from the original stones by the first publishers in Germany, and this explains some apparent discrepancy in the size of the illustrated pages—these having perforce to be printed on the same size of pages as the original German edition. Knowing the high regard in which the treatise has been held by the past generation of opticians, it is earnestly hoped that the present edition will prove equally valuable to the optician of the future, who is now studying the technique of the examination of vision in such a way that he should be greatly superior to his predecessors, and well worthy of adequately serving the needs of the community.

TABLE OF CONTENTS.

HAAB PLATES.

An Introduction to the Use of The Opthalmoscope.

The use of the ophthalmoscope for the examination of the fundus of the eye, is of course, a matter of the highest importance in recognising eye conditions which are departures from the normal, but, in addition, by the use of this instrument, it is possible to gain certain information as to the presence of disease in other portions of the body, such as the brain and the kidneys. It is also possible to observe the presence of general affections, such as syphilis and tubercle.

It may thus be claimed that the use of the ophthalmoscope provides a most important means of clinical examination—but, unfortunately, there are certain difficulties, since a fair amount of skill has to be attained before a clear fundus picture can be easily and readily seen, and even when that clear view is obtained, there are, at times, certain perplexities in correctly interpreting it.

To the beginner there is even some dilemma in differentiating between the healthy and the diseased fundus, and this difficulty can be appreciated later, when it is realised what a large number of varieties of the normal fundus can be seen.

To those who are content with viewing only the major details of the fundus, ophthalmoscopy may seem to be a matter of simplicity. Such an attitude is, however, a confession either of ignorance or carelessness, and to become a skilled user of the ophthalmoscope it is necessary to practice the more arduous task of observing, as well as interpreting, even the most detailed changes which are consequent upon the various diseased conditions.

To attain such skill, practice and experience are essential, but a certain amount of valuable aid can be obtained from the experience of other skilled observers, who have furnished both detailed descriptions and carefully drawn pictures of differing types of fundi. In furnishing the written description, however, there is always a certain amount of difficulty, in one observer explaining to another, exactly what he himself can see, especially if that other is a raw beginner with little or no experience. This is perhaps especially true of ophthalmoscopy, on account of the difficulty of describing details of the fundus and the exact location of certain changes. In describing the colour alone, one labours under a disadvantage, since even a slight variation in the exact

hue of various parts of a picture which the beginner might think was perfectly normal, some more skilled observer would recognise as important and perhaps be led to suspect serious changes.

It is certainly good practice for an observer to himself produce coloured fundus drawings, in that it trains his observation in the changes of colour tints, and however poor the result from the artistic point of view, any attempt is better than none, because the power of appreciation is also trained.

Such coloured fundus pictures have already been published in various text books, but invariably they have been mixed up with the text of the book, and very often the cases illustrated are of the rarest types of abnormal conditions, and examples of differing stages, even of the commonest abnormalities, are usually omitted, so that the student is given the impression of one particular condition always being represented by one definite picture. As examples, very little information as to the changes produced, is conveyed to a beginner by seeing only one or two pictures of such conditions as Albuminuric Retinitis and Chronic Choroiditis, and an attempt has been made to avoid such errors in this book. Furthermore, illustrations of such rare conditions as Cysticerus Sub-Retinalis have been entirely omitted, the space being more usefully filled by drawings of conditions of more general occurrence.

Many of the drawings which are produced, were made at different stages of the disease, so that the changes in the condition may be more easily followed and compared. In making the drawings, the indirect method was generally used, except in cases where the importance of detail rendered some resort to the direct method advisable. In consequence, some of the lesser important details, as for instance light reflexes from the blood vessels and the irregular mosaic-like pigmentation markings of the fundus are not always shown. Such details are not only bewildering to the student, but also present some difficulty in representation.

All the pictures are coloured for examination in full day-light. The original sketches were, of course, made by artificial light, and were found to be too yellow when examined in daylight—the requisite slight alteration in the colours has been adjusted therefore, so that when viewed in daylight, these pictures shall present a faithful representation of the fundi as seen in the dark room.

Explanation of The Ophthalmoscope.

Until 1851, when Von Helmholtz devised the ophthalmoscope, it was assumed that the interior aspect of the eye of a living subject was as uniformly black as the appearance of the pupil. Up to this time, surgeons and physicists were ignorant of the beautiful coloured pictures which the invention of Von Helmholtz disclosed, and the possibility of various diseases producing visible change in the retina had not even been hinted at.

Some explanation may be desirable as to why a special instrument such as the ophthalmoscope is necessary for the examination of the internal portion of the eye.

An analogy will explain, why the interior of the eye and the pupil appear black, except in the case of albinos. For this analogy take an ordinary camera ready to take a photograph. If we look through the uncovered lens—this appears to be as black as the human pupil. On raising the focussing cloth, however, if the camera is focussed, we can see on the ground glass screen at the back a perfectly coloured image of whatever view is in front of the camera. If, however, we again look through the lens we still see nothing of this image on the screen ; all appears to be dark with the exception of a small and faint image of ourselves, reflected from the lens, just as in a similar way we can observe the same image, reflected from a person's cornea—when we are looking at his eyes.

It is not difficult for anyone, who has a knowledge of the elementary laws of optics, to understand why the pupil appears black—nor why it is impossible to inspect the interior of the globe without special instruments. The refractive system of the eye consists of a double lens system, one part being the Cornea and Aqueous Humour, and the other the Crystalline and Vitreous, and as in a Camera Obscura, these form a reduced and inverted image of external objects on the retina. This image will only be sharply outlined, if the eye be correctly focussed for the object, and it will be blurred (by the formation of diffusion circles) if the eye be not correctly focussed, just as is the case with a photographic camera.

One of the laws of refraction tells us that there is a definite relationship between image and object—they are said to be conjugate or reciprocal—that is to say, they can be interchanged without the necessity of any change in the refracting system itself, or in the respective distances of image or object, from the nodal point of the lens system. If we hold a candle flame one metre in front of a photographic camera in a darkened room, a clear image is produced

on the ground glass screen of the camera, and if we then put the candle flame in the position of the ground glass screen, a clear image is obtained when placing the screen one metre in front of the camera lens, that is to say, in the same position as the light in the previous experiment. Thus, it is evident, we can interchange the position of the candle flame and the ground glass screen, and in each position obtain a sharply focussed image of the flame, if we take care to maintain the original distance, in the former case, behind, and in the latter case, in front of the camera lens.

Rays of light, which are emitted by the image formed on the ground glass screen, on passing through the apparatus would all return to the candle flame. When we look into any dark chamber, however, no light rays proceed from our eyes, so they cannot receive any in return. Thus, both the opening in the camera and the camera lens itself, look dark, and similarly the pupil of any eye into which we are looking, will also seem dark.

Should, however, light be emitted from the observer's eye, rays which had entered the eye under observation, could return to the observer's eye, and the pupil of the eye under examination would appear red like that of an albino.

Prior to the invention of the ophthalmoscope, the opinion was mistakenly held that the pigment in the fundus would absorb all light which entered the eye, and for that reason the pupil of any pigmented eye would appear to be black. If the fundus of a normal eye, however, is illuminated by light rays proceeding from an observer's eye, sufficient rays will be reflected back from the fundus, (which even in a heavily pigmented eye is not totally black), to allow of the observer seeing a clear image of the fundus so illuminated. On the other hand, an albino's pupil is red, not on account of any deficiency of pigment in the fundus, but because of some absence of pigment in front, so that light rays passing through iris, sclera, and choroid, illuminate the interior of such a globe at all points, instead of only at the focus of the refracting media. In such an eye, there would not be that same conjugate relationship between object and image ; rays would emerge from the pupil in all directions, and this would appear to be red because the fundus of the albino, (in man, and in rabbits, etc.) is coloured red by the large number of blood vessels in the choroid.

If light can be excluded from entering the eye of the albino in the abnormal ways through the unpigmented tissues outside the pupil, and it is then examined, it will appear just as dark as in any normal individual. This is easily demonstrated by placing immediately before an albino's eye an opaque cover perforated with an opening of similar size to the pupil. When light enters only through this perforated hole and the pupil, this latter appears to be just as black as that of a pigmented eye.

With the assistance of some simple device, and most easily with the help of the ophthalmoscope, rays of light can be sent as from the observer's eye. Even when holding an ordinary glass plate in front of the eye, because of its capacity for surface reflection, some rays from a light source placed at one side, will enter the observed eye. By placing a light therefore on the left-hand side of the subject, and inclining the glass plate slightly towards this light, so that a reflection of the light falls on the examined eye, a red reflex is immediately seen on looking at the pupil through the glass plate. (Fig. A.)

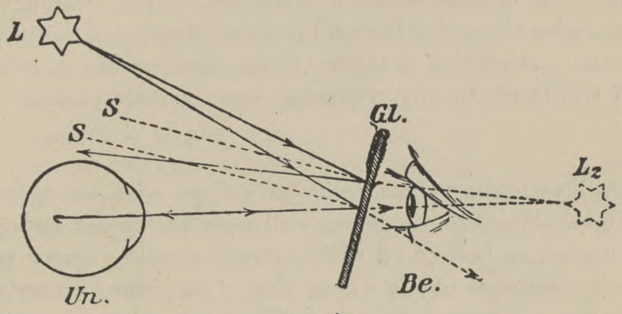

FIG. A.

The rays emerging from the lamp (L), are partially reflected into the subject's eye (Un.) by the reflecting surface of the glass plate (Gl.) and these rays enter it in such a manner that they have apparently come from some point behind the observer's eye (L2.), which will correspond to the reflected image of the lamp. On entering the subject's eye, they of course illuminate the fundus. If the subject then accommodates his eye for the distance of this reflected image, a sharply focussed image of the lamp would be produced on his retina ; if, however, it is not accommodated correctly for this distance, the image will be blurred. In any event some portion of the subject's fundus is illuminated, and therefore in a position to send back return rays of light. Such rays would return to the object, in this case the lamp, but since the glass plate not only reflects but also transmits light rays, a small portion of these returning rays from the subject's eye will be transmitted through the glass plate, and enter the eye of the observer, the remainder, of course, being reflected back to the lamp source and being lost to the observer.

The amount of light returning to the observer's eye in this instance is very small and consequently the illumination of the subject's pupil is apparently correspondingly weak. More light rays could be transmitted if, (as Von Helmholtz showed), several glass plates are placed over each other; but even then, there is comparatively only a very small amount of light entering the

observer's eye. If we reflect more light into the subject's eye, a much better result will be attained, since the fundus will be illuminated with greater intensity and more light rays will be accordingly sent back, and additionally if a perforated mirror be used, more of these returning rays will enter the observer's eye through the peep-hole. Thus a mirror, reflecting a greater amount of light into the observed eye, was soon substituted for the glass plates used by Von Helmholtz. The silvering was scraped away from a small spot in the centre of a mirror, so that such an opening would permit of returning rays entering the observer's eye. By substituting a concave mirror which converges the beam of light before it enters the subject's pupil, the intensity of the light, entering the eyes of both subject and observer, is still more increased, and if an actual perforation is made at the centre of the mirror, there is a minimum of resistance to any returning rays, in their passage back to the observer's eye.

Thus, by illuminating the interior of an eye with the somewhat weak Helmholtz Ophthalmoscope, or better still with the rather stronger but still weak plane mirror, or best of all with a strong concave mirror perforated at the centre, it is possible to obtain a clear view of the otherwise invisible fundus, since the observer can have a clear image focussed on his own retina, by those rays emitted from the subject's illuminated fundus. In other words, the subject's fundus becomes a luminous object which can be seen like any other object in the outside world. To be strictly exact, however, this fundus is seen as an object through a magnifying glass, the refracting media of the subject's eye acting as a convex lens, through which is viewed, the separate portions of the background of the eye, under a certain amount of magnification.

In the case of some observers, in order to obtain a distinct view, additional lens aids will be required in the method still to be described.

This manner of inspecting the fundus is known as the direct method, or, the method with the erect image. It is called the direct method, on account of it allowing a normal eye to examine another normal eye, or even one with hypermetropia, without any additional lenses, and it is called the method of examination with the erect image, because it enables us to see the subject's fundus right side up, just as we would any other object in the outside world.

The Use of The Ophthalmoscope.

THE EXAMINATION OF THE ERECT IMAGE.

Unless one makes use of certain known methods of altering the direction of light rays, emerging from an observed eye, this particular method of examination is frequently quite impossible, and so we arrive at another very important peculiarity of Ophthalmoscopy.

One should not only be able to examine all the details of structure which the ophthalmoscope reveals, when looking at the fundus, but we should be able to accurately measure the refractive power of the eye under observation. Such information is additionally valuable since the method is entirely objective, being quite independent of any statements made by the patient. For this purpose, we use our own eye, together with the refractive apparatus of the patient's eye, and possibly some convex and concave lenses in addition. Thus, in a comparatively simple manner, it is possible to estimate the refraction of an eye under examination. In order to clearly understand this possibility, we must first of all visualise the way in which incident rays of light will emerge from the fundus, in the case of a normal, a shortsighted, and a long-sighted eye, respectively.

It has already been made clear that light rays will return to the point from which they have been emitted, and on which the eye is therefore focussed—thus, in the case of the illustration already given—they would return to the candle flame placed at a distance of one metre away from the eye. Such an eye is described as being *accommodated* for one metre.

If a normal or emmetropic eye is unaccommodated, the focus is adapted for infinity, that is, for incident rays which are parallel. On the fundus of such an eye, there will be produced a sharply focussed image of all objects emitting parallel rays of light, that is to say, all distant objects. The diameter of the pupil being however comparatively small, any object which is three to five metres or more away from the eye, may be considered as a distant one, since any error induced by regarding rays coming from such a point as being quite parallel, is negligible. If such an emmetropic eye, therefore, is focussed for infinity, or looks at any object three to five metres distant, returning light rays from the illuminated fundus would emerge parallel, or would return to infinity (c.f. Fig. B). Thus, it will be evident, that in any emmetropic eyes examined by this direct method, the emergent light rays will form a sharp image of the fundus on the retina of the observer's eye if he also looks into infinity, that is to say, if he adjusts his eye for parallel rays. If this observer

accommodates, however, he will only receive a blurred image of the patient's fundus. In order to examine an eye in this manner, it is necessary to get as close to it as possible—just as if trying to examine a room through a keyhole, and under such circumstances it is rather difficult to relax one's own accommodation. This proves to be one of the greatest difficulties experienced by a beginner, when attempting to use the direct method.

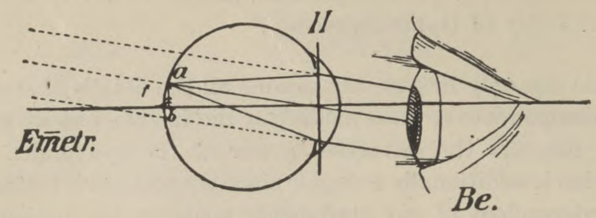

Fig. B.

Attention to this point is essential, however, for accurate estimation of the refraction of an eye ; in other words, the observer, in order to measure the refractive power of the observed eye, must totally relax his own accommodation because of the impossibility of calculating the increase in refractive power of his own eye, on account of such accommodation. It is only possible to measure our own accommodation, when we know for what definite distance the eye is focussed, that is, for a known degree of divergence of the light rays *entering* the eye. With examination by the direct image, we are attempting to determine the unknown degree of divergence of light rays *leaving* the eye. From what has been already said, it will be seen that it is essential that the exact refractive power of his own eye should be known, if an observer is to estimate that of a patient's eye. Should the observer be emmetropic, he will obtain a clear image of the patient's fundus without any additional apparatus. If he be myopic, however, he will see a blurred image, since whatever object sends out parallel rays, in fact, all rays coming from infinity to his own eye, will appear blurred and out of focus.

For seeing distant objects clearly, the myope must use spectacles with concave lenses and in the same way, in order to examine by means of the direct method, he must use a correcting lens, which can be placed behind the peep-hole in the ophthalmoscopic mirror, if he wishes to see clearly the fundus of any emmetropic eye.

Should the observer be hypermetropic, when he tries to examine by the direct method, he is in a similar situation to that which obtains, when he is looking into infinity. Since his eye is not focussed for parallel rays, he must either use correcting glasses fitted with convex lenses, or he must accommodate.

Whilst examining, however, he must not employ this latter alternative—so he should use a convex lens correcting his own hypermetropia, which also can be placed behind the hole in the ophthalmoscopic mirror. Such hypermetropia should be fully corrected, so that there will be no necessity to provide for any uncorrected defect, by making any use at all of his own accommodation. This is a point of difficulty for hypermetropes, since it is habitual for them to correct a part of their error by accommodating, and they do not easily suspend this habit, even when a correcting lens is fitted, but continue to accommodate to some extent, even when looking through the correcting lens, so that they are, in effect, over corrected. This is notably the case in the higher degrees of hypermetropia, and also in younger people, when the power of accommodation is vigorous.

Strong hypermetropes, therefore, if they wish to make use of objective methods only, for refracting a patient's eye, must employ alternative methods of measurement, such as, either the Schmidt-Rimpler method, by means of the inverted image, or the shadow test. Both of these methods will be described later.

We have so far assumed that the patient is emmetropic, and that the observer is emmetropic or myopic or hypermetropic. What will be the condition when an eye with abnormal refraction has to be examined? We must first investigate how light rays emitted from an illuminated fundus will emerge from an eye, in cases of myopia and hypermetropia.

Once again, we will take it for granted that any emmetropic eye, whilst being examined, is looking into infinity, so that any effort of accommodation, which could not be measured, will not interfere with our results. Even the normal sighted subject, as well as emmetropes, must accommodate as little as possible, whilst their refraction is measured.

THE MEASUREMENT OF THE MYOPIC EYE.

If a short-sighted eye is not accommodating, it is focussed for a point situated at one fixed distance, and the nearer this point is to the eye, the greater is the degree of myopia. This point is called the far point (punctum remotum). It is the farthest point to which such an eye can see distinctly. Only those light rays which come from this point are focussed on the retina, forming there a sharp image, if the eye does not accommodate, and looks into infinity. Those rays which come from any more distant point are focussed before reaching the retina, so that the retinal image is indistinct. This image is formed in front of the retina, instead of on it, as in the normal eye—because as a rule the myopic eye is too long (c.f. Fig. C), or because its crystalline lens

has too strong a refractive power. A myopic eye will see clearly at a distance, if we give it help in the form of a correcting concave lens. This weakens the refractive power in myopic eyes, so that the images are focussed on the retina behind the focal position of the lens.

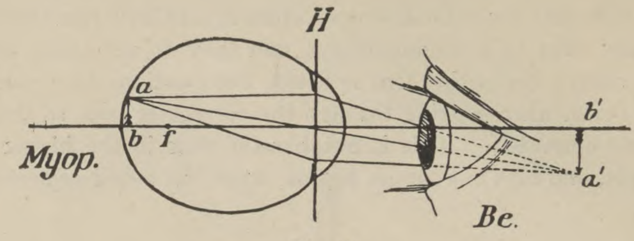

Fig. C.

We will now consider those light rays which will emerge from the illuminated fundus of such a myopic eye after returning through the refractive media of the eye. If the eye is unaccommodated for distance vision, these rays will converge to the far point (c.f. Fig. C), this far point being at a definite distance from the eye, (a′b′ is the plane of the far point). Should this far point be one metre distant from the eye, the amount of myopia is one dioptre, and the refractive error will in this instance be corrected with a lens which has a focal length of one metre. If this far point had been 0·5 metres from the eye, the error is twice as great, and the required lens for correction must be twice as strong, that is, a two dioptre lens or one which has a focal length of half a metre. Should the distance of the far point be 0·25 metres or 25 cms, the amount of myopia is four times as great, or four dioptres, and the correcting lens will have a focal length of 0·25 metres, or 25 cms., etc. In this last case, for example, the myopia is corrected by means of a concave lens of four dioptres, (having a focal length of 25 cms.), because, if this lens is held closely in front of the eye, parallel light rays coming from infinity are made so divergent, that they appear to come from the far point, which is 25 cms. in front of the eye. A concave lens of four dioptres would give such divergence to parallel rays, that they would apparently proceed, as from the focal point of the lens, which is equal to 25 cms.

Thus light rays leaving a myopic eye will converge to its far point. If a normal eye is now placed behind the ophthalmoscope, it will see nothing of the fundus, since such an eye is not focussed for a converging beam of light, for converging rays do not happen without some unusual cause. The examining eye, must therefore, have an additional lens behind the mirror, and its strength must fully correct the myopia in the examined eye ; or, in other words, the required strength of the lens will render parallel the emergent rays

from the myopic eye, and the normal eye will be focussed for these parallel light rays. In this way, one can estimate the amount of myopia in the examined eye by finding the weakest possible concave lens with which it is possible to see the fundus clearly. The weakest concave lens must be the one selected, so that the examiner's own accommodation is quite eliminated. It would be possible to see quite clearly with a stronger concave lens, so long as, by means of his own accommodation, he could neutralise the excess concave power of the lenses used.

Should the observer be also myopic, in order to see clearly another myope's fundus, he will require a concave lens, which corrects both his own and the other's myopia. For example, if he found that a five dioptre was the weakest concave lens which enabled him to see the fundus clearly, and he himself has myopia of two dioptres, the one under examination will have three dioptres of myopia.

On the other hand, should the observer be hypermetropic, say, to the extent of two dioptres, and he found the correcting concave lens to be five dioptres, he must add on the amount of his hypermetropia, and the patient thus has seven dioptres of myopia.

An emmetropic observer would require a concave lens of seven dioptres in this case, while the hypermetrope needs only five, since his own error of two dioptres convex, will neutralise the effect of a two dioptres concave lens. He will need the full seven dioptres, if he used his own correcting lens of plus two dioptres, when looking through the ophthalmoscope. It is better, however, to only have one lens behind the ophthalmoscope mirror, so he will need only —5 instead of —7 dioptres to correct the subject's myopia.

THE MEASUREMENT OF THE HYPERMETROPIC EYE.

So far, we have considered the conditions when the subject's eye is emmetropic or myopic, there still remains the possibility of hypermetropia.

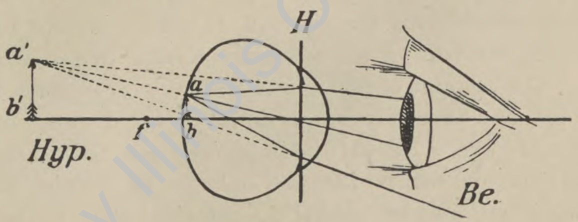

Fig. D.

First of all, it should be made clear, how light rays will emerge from such an eye, when its fundus is illuminated with an ophthalmoscope. An unaccommodated hypermetropic eye is focussed for neither parallel nor

divergent rays, only for convergent (see Figure D), that is to say, a clearly focussed image is only formed on its retina, when a converging beam is refracted. If parallel rays enter the eye, they will form an image behind the retina, at the position "f," either on account of the axis being too short, or the refractive media being too weak, as happens in cases where the crystalline lens is absent. Whatever is the causation, the refractive system of an hypermetropic eye is insufficient for the axial length, and so an additionally converging lens is required. By the exertion of its own accommodative power, this can be done by increasing the refraction of the crystalline, so that the image is focussed further forward on the retina. In contrast with the normal eye, the hypermetrope must of necessity accommodate, when looking into infinity. Such accommodation, however, is unnecessary if a correcting convex lens is placed in front of the eye. In many cases, the amount of error in the hypermetropic eye is insufficiently corrected by such a lens, and the subject will then correct the remaining portion, by the exertion of some accommodation. In fact, with young persons, whose accommodation is very active, it is impossible to fully correct the total hypermetropia, by testing with lenses. Such cases always accommodate to some extent, when fixing any object, and they accept subjectively a convex lens which only partially corrects their hypermetropia. Such a portion is called the *manifest hypermetropia* of the subject, whilst that portion which is self corrected and remains undisclosed, is called the *latent hypermetropia*. With advancing years, and diminution of the power of accommodation, the manifest hypermetropia will increase. Should the faculty of accommodation be entirely negatived, either by age or the use of such drugs as atropin or homatropin, the total amount of hypermetropia is disclosed.

A very convenient method of estimating a subject's total hypermetropia, without resorting to artificial paralysis of the accommodation, is provided by examination by means of the erect image, since a hypermetrope, even if young, will not accommodate during an examination with the ophthalmoscope, if looking into infinity in a darkened room, and having no visible object to focus. Rays of light leaving the eye will, therefore, emerge in the direction demanded by the structure of the refractive media, that is to say, they will be divergent. The amount of divergence will be in proportion to the amount of hypermetropia, and inversely proportional to the distance of the negative far point behind the eye. Should the hypermetropia, for example, be of such an amount that the eye will be focussed only for rays which would converge at a point which is half a metre behind the principal plane of the eye, the error will be corrected by means of a convex lens of two dioptres—which also has a focal length of half a metre. Should the incident rays require an even larger amount of convergence to be focussed on the retina, say to a point 25cms. behind the eye, (that is, if the negative far point was a quarter of a metre behind

the principal plane,) then the amount of refractive error must be twice as great. The measure of the hypermetropia is therefore four dioptres, and the necessary correcting lens will be of the same strength, unless when looking into infinity the subject exerts his accommodation to the extent of four dioptres. If a lens of four dioptres be placed before such an eye, therefore, the requisite added degree of convergence will be supplied to all rays coming from infinity, for such a lens, in front of the eye, will refract parallel rays entering the eye, as if they were converging to a point 25 cms. behind it, that is, to the far point of the eye, the distance separating the position of the lens and the principal plane of the eye, being considered as negligible.

The same correcting lens will form a parallel beam of any diverging rays emerging from the eye, since they will come as from the focal point of the lens. A similar result will be approximately produced, if a lens of the same power is placed behind the ophthalmoscope mirror. Any emmetropic observer will see the fundus clearly, on examining such an hypermetropic eye. He could even see it without the use of any correcting lens, if he sufficiently used his own accommodation, (as in the case under consideration, to the extent of four dioptres), but this would be a source of error if he were estimating the refractive power of the subject.

Should the observer be also hypermetropic, his own correction must be added to that required by the subject. To estimate the subject's error, he must therefore subtract his own correcting lens from the total convex lens used. In such a case, it is advisable to use the strongest convex lens with which the fundus can be clearly seen, so that there is no possibility of some proportion of the hypermetropia being neutralised, by the exertion of the observer's accommodation.

On the other hand, if the observer is myopic, a weaker correcting lens will be required, than if he were emmetropic, since his own error tends to neutralise the error of the subject's eye. For example, if the observer's eye be focussed for rays coming from a point 20 cms. distant (myopia five dioptres), without the exertion of any accommodation, his eye will be focussed for emergent rays from an hypermetropic eye of five dioptres, so that no correcting lens would be needed. In such a case, the hypermetropia of the patient is equivalent to the myopia of the examiner. If the observer needs a convex lens, he must add its value to his own degree of myopia. For example, if his own myopia is three dioptres and he required a plus 2·0 dioptre lens to see the fundus clearly, the patient must have hypermetropia to the extent of five dioptres. A myope of seven dioptres, needing a —3 dioptre lens would indicate that the patient's hypermetropia amounted to four dioptres.

Those who are as yet inexperienced in these matters, should always remember (c.f. Figures B, C, and D), that in the emmetropic eye the emergent rays are parallel, in the myopic eye they are convergent, and in the hypermetropic eye divergent, and conversely if no accommodation is exerted an emmetropic examining eye is focussed for parallel rays, a myopic one for divergent and a hypermetropic one for convergent rays. From what has already been said, the following general rules may be laid down :—

If an ametrope, in order to see clearly another's fundus, requires—

1. A Lens of the same denomination as that required for correcting his own defect, but of greater power, he must subtract the dioptric strength of his own correction from the total power of the lens used, to arrive at the subject's refractive error.

2. A Lens of the same denomination, but from 1 to 10 dioptres weaker, than that required for correcting his own defect, then the refractive error in the patient's eye is opposite in kind, and amounts to from 1 to 10 dioptres. (For example :—If an observer with six dioptres of myopia finds a —5 dioptric lens is necessary, then the subject's eye has an hypermetropic error of one dioptre. If the same observer needed a —4 dioptre lens, the subject then has two dioptres of hypermetropia, etc. Should the observer have hypermetropia of four dioptres, and needs a plus three lens, then the subject has myopia of one dioptre, etc.)

3. A Lens of the contrary denomination to that which corrects the observer's ametropia, the measure of the subject's refraction, is the dioptric sum of the powers of the lens needed behind the mirror, and that of the observer's emmetropic correction, and the type of error is opposite in kind to that of the observer.

   (For example :—If an observer with five dioptres of myopia needs a plus three dioptre lens then the subject has eight dioptres of hypermetropia, or if the observer has hypermetropia of three dioptres and needs a —2 dioptre lens, the subject has five dioptres of myopia).

For correcting the refraction of the eye with absolute accuracy, the following precautions must be observed :—the refractive condition for that portion of the fundus which forms the position of clearest vision, namely, the macula lutea or fovea centralis of the retina, must be determined. Thus the examiner must obtain a sharp clear view of that portion of the fundus when estimating the refraction of an eye. A clear view of the macular area

is unfortunately very difficult, because the pupil will contract, as soon as an attempt is made to examine it, and there is a reflection of the light source seen on the cornea, which is very confusing. Further, it is not an easy matter to judge the sharpness of one's perception sufficiently when looking at the macula lutea. There is a lack of any characteristic markings, and the retinal vessels in this part of the fundus are very inconspicuous. One sees nothing but a fine stippling, due to a somewhat varying proportion of pigment cells, forming the layer of pigmented epithelium of the retina. The darker the fundus, the more uniform is the appearance, and the less is one able to focus sharply. It is certainly true, that in the darker fundi, especially in younger people, there is to be seen a small bright sickle or ring-shaped reflection of the light, at the bottom of the fovea centralis. This reflection lies a little in front of the retina, but so very little, that it need not be considered when calculating the refractive power. Where the foveal reflex cannot be used in this way, on account of its lack of distinctness, it is better to select some of the vessels passing from the disc to the macula lutea, or one running towards the macula from either above or below.

The beginner is well advised to restrict himself to the temporal edge of the disc, since it is more crisply defined, and the presence of blood vessels passing over it towards the macula (c.f. Plates 1, 4, etc.) gives an opportunity to take measurements in the different meridians of the eye.

By such means one can also estimate the so-called astigmatism of an eye.

THE MEASUREMENT OF THE ASTIGMATISM.

With this name, astigmatism, one classifies those abnormal refractive conditions of the eye, in which, one or more of the refracting surfaces are not spherical or slightly parabolic in shape, but have greater curvature in one meridian than they have in another, at right angles to it. If the divergent beam from any luminous source meets a refractive surface of equal curvature, in all its meridians, as for example, the spherical surface of one of our glass lenses, the refracted rays will all meet at a common point focus (ignoring the marginal rays which meet the surface of the lens at its periphery). If the same divergent beam meets a refracting surface with a weaker curvature in the horizontal than in the vertical meridian (c.f. Fig. E) the rays, which pass through the vertical plane, will be refracted more than those passing through the horizontal plane. Such a surface has two foci, and the rays emanating from a luminous point (a homocentric pencil) will not come to a focus at any one point beyond the refracting surface, hence the name astigmatism (α deprived of, $\sigma\tau i\gamma\mu\alpha$ a point).

Since each point of any luminous object must have a corresponding point in the image, if a sharply focussed image is to be procured, it is obvious that with an astigmatic surface, a distorted image only can be produced. In the same way, any retinal image in an astigmatic eye will be distorted, whether the abnormality of curvature is situated in lens or cornea, and conversely, if such an eye is examined ophthalmoscopically, any elements of the fundus (whether disc or retinal vessels or any other feature), will appear to be distorted, and it will be impossible to focus them up clearly, with any additional spherical lens. The type of lens that will be required, must have refractive power in one direction only, that is, a so-called *cylindrical* lens. A lens having no curvature in a vertical direction, but a certain convex power in the horizontal, would neutralise the abnormally weak horizontal curvature of the refracting surface, in the case already quoted (see Figure E). There are ophthalmoscopes which provide for the use of such cylindrical lenses, they are not, however, strictly necessary for the estimation of the amount of astigmatism. With a little experience, it is quite possible to estimate the refraction in each of the different meridians.

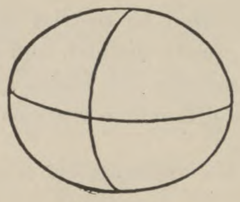

Figure E.

It should, however, be noted that the vertical meridians of any spherical or sphero-cylindrical lens, will correct the horizontal and not the vertical plane of an object, and, *vice versa*, the horizontal meridian will correct vertical and not horizontal planes. If one sees clearly with the ophthalmoscopic mirror, the vessels running horizontally from the disc to the macular area, it indicates that the refractive power of the vertical meridian of the subject's eye has been correctly measured. A differing power of lens would be necessary, in order to see clearly the vertical vessels, (such for example, as travel towards the macula from either above or below), or the edge of the disc at the temporal side, where at one point it is approximately vertical. This second lens would indicate the refractive power of the horizontal plane of the patient's eye.

It might so happen, that the chief meridians were not vertical and horizontal, cases where these directions are oblique often being met with. One will then see those blood vessels, in the neighbourhood of the optic disc, which run in an outward and upward direction, quite clearly with one particular lens, whilst at the same time, such vessels as have a downward and outward

direction, will seem to be blurred. One must choose a different power of lens for focussing these latter vessels, and with this second lens, the first vessel running outward and upward will now be indistinct. In thus estimating the amount of astigmatism, it is very important that the act of accommodation be suspended by both observer and subject.

One should be especially careful when taking such measurements, not to look through the correcting lenses obliquely. This possibility should be avoided absolutely, otherwise astigmatism will be found where none is actually present, or under certain circumstances, astigmatism may be corrected without the observer's own knowledge. If an ordinary spherical lens be looked through obliquely, the unequal refractive effect of a regular astigmatism, such as we are now describing, is produced.

There still remains to be described, what is known as *irregular astigmatism*. This is found in cases where the refracting surfaces are irregular in curvature, as for example, when the surface is uneven. The image will then be quite blurred, and cannot be made to seem distinct, for any long duration, by any means whatsoever. Usually, such irregular astigmatism is the result of irregularities in the corneal surface, which correspond to more or less noticeable opacities. Such affections of the cornea can be best examined by means of oblique illumination. A final point for consideration when estimating refractive errors with the ophthalmoscope, by means of the direct method, concerns the distance apart of the observer's eye and that of the subject. This should always be as short as possible, or the correcting lens used in the ophthalmoscope will be too far removed from the patient's eye, and the refractive power therefore changed. A concave lens is thus lessened in power on increasing its distance from the eye, and conversely, a convex lens will be increased in power when the distance from the eye is increased. (This is why elderly people often push their spectacles down towards the tip of the nose, in order to increase the effective refractive power).

Any error introduced from this cause, would require adjustment, if the correcting lenses were strong ones, but may be ignored if they be weak, especially since any spectacle lenses that may be worn to correct the ametropia, will also be worn at some distance in front of the eye.

It should always be remembered, however, when using strong powers, that the correcting lens as found with the ophthalmoscope, will be rather too strong in cases of myopia, and too weak in cases of hypermetropia, if the observer's eye is not far distant from that of the subject. The subject's myopia therefore will be slightly weaker or his hypermetropia slightly stronger, than is indicated by the lens used in the ophthalmoscope.

SIZE OF THE OPHTHALMOSCOPIC FIELD OF VISION.

The closest possible proximity to the examined eye is again required, because inspection of the eye through a comparatively small pupil is thereby facilitated. If one gets as close as possible to the pupil, a much larger area of the fundus can be seen, without being compelled to change the positions of either the observing or the observed eye. The ophthalmoscopic field of vision is thereby increased. If the pupil is very small, so that free inspection is not possible, then it must be dilated. When this is necessary, it can be done by protecting the subject's second eye from any light, or by the use of certain mydriatics, such as a 2 % solution of homatropin, or a 5 % solution of Euphthalmin—if two to three drops of either of these be instilled, in many cases, within five minutes, and almost always within twenty minutes, a requisite amount of dilatation is procured. The use of Atropin for such a purpose is to be greatly deprecated, because the effects of this drug last too long, and it may induce a very serious condition, in the form of that increased tension of the eye, which is a cause of Glaucoma.

The greater the experience of the observer—the less will he require artificial dilatation of the pupils of average eyes, unless he particularly wishes to examine the macular region in detail. For this purpose, dilatation is necessary, especially in the case of elderly people, whose pupils are usually smaller than those of young people. For similar reasons, the perforation in the ophthalmoscopic mirror should not be too small, the best width being 3·5 mms.

The size of the ophthalmoscopic field of vision is further influenced by the refraction of the subject. The field is greatest in conditions of hypermetropia, because, as has been shown, the rays are divergent on leaving the eye; it will be smaller in emmetropia and smaller still in myopia, the emergent rays being convergent.

Again, the ophthalmoscopic field during examination by the direct method, is dependent on the size of the illumination employed, especially if a strong concave mirror is used, one with a focal length of 16 centimetres for instance, which is the type used in the indirect method of examination, which is shortly to be described. With such a mirror, an inverted image of the illuminant often appears on the fundus, and clear vision is restricted. Beginners, however, are well advised not to use too small a light source.

If the illumination of a fairly large field is required, a concave mirror of very short focal length should be used. The complication of the instrument by fixing a third mirror is, however, unnecessary.

We are thus brought to the question of the choice of a mirror for the direct method. In addition to the very strong concave mirror just mentioned, which is most suitable for beginners, either a plane mirror or one with a focal length of about 16 cms. may be chosen. This latter is the type used in examination by the indirect method, and is much preferable for examining the macular area, as on account of its darker pigmentation, this reflects little light. A plane mirror does not illuminate the macula sufficiently, and additionally, on account of an absence of glare, the pupil keeps more dilated.

II. EXAMINATION WITH THE INVERTED IMAGE.

This method, which is also known as the indirect method, was first introduced by Von Rute. It is based upon the illumination of the fundus, by means of a concave mirror, and a strong convex lens (13 to 20 dioptres), which is held in the plane of the near point, that is, at a distance of from 5 to 7·5 centimetres from the patient's eye, so that all emergent rays from the patient's eye are united to form a real and inverted aerial image (c.f. Figure F, where the observer's eye is depicted as being nearer to the patient's than it should be, in order to save space). The observer, who in this method places himself at a greater distance away from his patient, can clearly see, through the hole in the mirror, as it were in front of the lens, the inverted image. Since he must of necessity accommodate, in order to see this image, he should be at a fixed distance from the patient of from 25 to 30 centimetres.

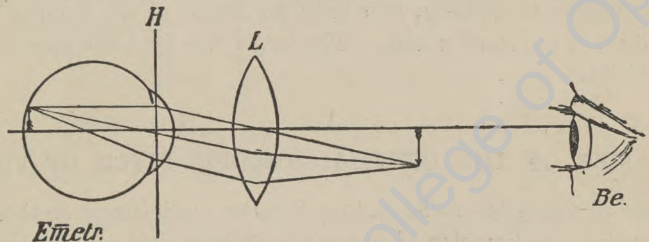

Figure F.

In cases of strong myopia, an observer can see an inverted image of the fundus, in this way, without the assistance of any supplementary lens, as will be seen on reference to Figure C. The light rays emerge from such an eye so very convergent, that they will form a real inverted aerial image at the far point of the eye. So, if simply by illuminating the eye and peering through the hole in the mirror, the red fundus reflex is seen, with clearly defined retinal vessels and part of the optic disc, in the form of an inverted image—we conclude there is a high degree of myopia present. In order to be sure whether this fundus image is an inverted or erect one, the observer should move his head to one side, and notice whether the image moves in the same or an opposite

direction. One should make quite sure of this point before a diagnosis of myopia is made, for it is possible to see a partial and erect image in the pupil, by simply reflecting light into the eye, from a certain fixed distance. This would occur if the patient's eye had a high degree of hypermetropia, and would be caused by the emergent rays from the eye being divergent (as is shown in Figure D). On account, however, of the observing distance being great, the field of view is small, and one only sees a very small section of the fundus, and this image moves in the same direction as any movement of the observer's head.

With the assistance of a convex lens, one can obtain the inverted image with any eye, that is to say, any eye can be made similar to a myopic eye. According to the refractive condition, however, the distance of the inverted image will appear nearer to, or further from, the auxiliary lens. Should the subject's eye be emmetropic, the emergent rays will be parallel, and the inverted image will be in the focal plane of the auxiliary lens. In cases of myopia, it will be nearer the lens, and in cases of hypermetropia, it will be beyond the focal plane. Assuming that the observer does not exert his own accommodation, he should move his head back, in order to examine any very hypermetropic eye. Actually, however, it is better to vary the accommodation, so that the image will be nearer to the observer. The auxiliary lens should be so held, during this form of examination, that its distance from the subject's pupil is the same as its own focal length. The pupil and the iris will then apparently disappear entirely, and only an image of the fundus is seen over the entire limit of the convex lens. The larger this lens, the greater is the area of fundus visible.

THE SIZE OF THE OPHTHALMOSCOPIC FIELD OF VISION.

The size of the field of vision, therefore, by the indirect method, is mainly dependent upon the diameter of the auxiliary lens, and also on the refractive condition of the subject's eye, and the focal power of the lens. The greater the subject's myopia, the larger will be the ophthalmoscopic field of view, and the greater the hypermetropia, the smaller it will be. The nearer the auxiliary lens is held to the eye, that is, the stronger it becomes in effect the larger a pencil of emergent rays will it receive, and therefore the greater will be the visual field. And lastly, just as in the direct method of examination, the greater the area illuminated by the ophthalmoscopic mirror, the larger will be the area of the visual field. The illuminated area, is much more with the indirect method, than is the case with the direct. The intensity of illumination is also higher, since it is usual to use a concave mirror for the former method. The size of the ophthalmoscopic field does not depend so

much on the diameter of the pupil in the indirect method, as it does in the direct, in other words, even with a very small pupil, a fundus can be distinctly seen, although the smaller pupil necessarily cuts off a great number of the light rays, and the image will appear less distinct in such cases.

Summing up what has been said so far, the indirect possesses the following advantages over the direct method :—

1. The distance from the subject is greater, making the examination less trying to both him and the observer.
2. The observable field is greater, so that a larger fundus area can be examined at one time.
3. The use of correcting lenses in the ophthalmoscope is obviated.
4. Examination is possible even with small pupils.

On the other hand, with the indirect method, the degree of magnification of the fundus is smaller, and that is the chief difference between the two methods.

ENLARGEMENT OF THE IMAGE IN THE DIRECT AND THE INDIRECT METHODS.

The degree of magnification of the image seen by the *direct method* depends upon certain conditions :—

1. The refractive power of both the observer's and the patient's eye.
2. The distance between the observer's eye and that of the patient.
3. The distance between the correcting lens and the subject's eye.

For emmetropic eyes the magnification was estimated to be $14\frac{1}{3}$ times by Von Helmholtz ([1]), and later by Mauthner ([2]).

L. Weiss ([3]) obtained an approximately similar result—15·6 times—by direct measurement in the case of a dead eye that had been carefully examined also during life. With hypermetropia, the degree of magnification will be a trifle less, and with myopia slightly more than in cases of emmetropia, assuming that any correcting lens is placed three centimetres away from the examined eye. Should the hypermetropia be the result of unusually weak refractive power, as for example, in aphakia, the image will be smaller than

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(1). Von Helmholtz "Handbuch der Physiologischen Optik," Second Edition p. 217.
(2). Mauthner "Lehrbuch der Ophthalmoskopie," p. 177.
(3). L. Weiss "Arch. f. Ophthalmologie." Vol. XXIII.

when the hypermetropia is due to a decreased axial length, and in cases of myopia, it will be smaller in cases of increased axial length, than when the refractive power of the ocular system is abnormally strong. (Mauthner, loc. cit. p. 185).

With hypermetropia, the magnification is less if the distance of the correcting lens from the eye is increased, and conversely, the magnification is increased in myopia, if the distance of the lens from the eye is increased. (Mauthner, loc. cit.)

With the *indirect Method*, the degree of magnification depends almost entirely on the power of the auxiliary lens ; the stronger this lens, the smaller is the magnification (but the greater is the ophthalmoscopic field of vision). According to Von Helmholtz (loc. cit., p. 218) we should obtain a magnification of three times, using an auxiliary lens of twenty-two dioptres (focal length 45 mms.), and a magnification of four times with a lens of 16·6 dioptres (focal length 60 mms.), using Listing's Schematic eye as a basis of calculation in both instances. The refractive condition of the subject's eye also needs some consideration. Thus in hypermetropia, the magnification will be somewhat increased, and in myopia it will be slightly diminished.

According to Mauthner (loc. cit., p. 230) the magnification is greater in cases of hypermetropia, when the axial length is decreased, than in those cases where the refractive power of the dioptric system is reduced ; and conversely, the magnification is less with myopia due to increased axial length, than when caused by increased refractive strength of the dioptric system.

By contrast, therefore, with the direct method, the fundus will appear to be appreciably enlarged from twelve or fourteen up to twenty diameters, but with the indirect method, the magnification will only be from two or four, up to eight-fold, with an auxiliary lens of seventeen dioptres, which is the most suitable strength for this method of examination.

The indirect method, on the other hand, as has already been stated, has the advantage of providing an enlarged field of view, thus, in order to make as speedy an investigation as possible, one should first examine by means of the indirect method, and then estimate the refractive condition, and make a further examination by the direct method with its increased degree of magnification.

The refractive condition of an eye can also be estimated by means of the indirect method, and this can best be done in the manner devised by Schmidt-Rimpler ([1]), because it does not necessitate any relaxation of the observer's accommodation, which very frequently (especially in the case of hypermetropes),

(1). Schmidt-Rimpler "Augeheilkunde und Ophthalmoskopie." 6th Edition, p. 196.

is a matter of difficulty. By means of a special apparatus, the position of the inverted fundus image, or rather, its distance from the auxiliary lens, is determined. (Ref. Fig. F). Referring back to what has already been explained on pages 7 and 8, if rays emanate from some luminous source, and illuminate the retina, the positions of this light source and the retina are conjugate, and, after reflection from the fundus, some rays will return to the light source. Whilst relaxing the accommodation, by using such a light source it is possible to estimate the absolute refractive condition. By means of a strong convex lens placed in front of the subject's eye, it is first of all rendered myopic, so that all emergent rays will form an inverted image in front of the eye. For example, in emmetropia, an additional plus 10 dioptre lens will form this image 10 cms. in front of the auxiliary lens. It is not necessary to use the actual luminous source, but rather the inverted and real ophthalmoscopic image formed of the actual light source, which is placed to one side of the patient. If the observer, looking through the ophthalmoscope, then moves the mirror backwards or forwards until, apparently, an inverted image of the light source is seen on the fundus, then the retina and the image of the light source are conjugate, and since the distance of the light source from the mirror of the ophthalmoscope can be measured, the far point of the patient's eye can thus be determined, subject, of course, to his having relaxed his accommodation entirely, by looking into infinity. If we know the far point of a myopic eye, we can calculate its refraction. This method of Schmidt-Rimpler's will only provide good results if the subject exerts no accommodation, but he almost certainly will, as soon as the macular area is illuminated, or while the observer is endeavouring to estimate the refractive condition. If the subject's accommodative power be not paralyzed by the use of a drug, one is compelled to measure the refraction of a point on the retina between the macula and the disc.

By means of both the direct and the indirect method, we are also able to determine surface irregularities on the fundus, and, if one is skilled in the use of the direct method, even to measure their depth. Such an irregularity occurs, if the optic nerve head is excavated, so that in place of the usual disc area, one sees a more or less deep cupping. Another alteration at the disc. area is of equal importance, when it bulges forward more or less like a mound, Furthermore, it may happen that a neoplasm or some foreign body on the fundus, may project forward into the vitreous. If therefore, in such eyes, the whole retina appears to be emmetropic, except the floor of a cupped disc, apparently lying beyond the refracted plane of the eye, there will be an appearance of myopia. Should the disc area appear more prominent and apparently projecting forward, whilst the surrounding retina appears to be emmetropic, the more prominent portion will suggest hypermetropia, since

its distance from the lens seems to be diminished (c.f. Figure B, p 12). On the other hand, if the retina surrounding the disc indicates a degree of hypermetropia equal to 5·0 dioptres, whilst the floor of the cupped disc shows myopia of 5·0 dioptres, there will be, between the two planes, a refractive difference of 10·0 dioptres, and from this can be calculated a depth difference of 3·47 millimetres. By similar means, it is possible to measure the projection of a swollen nerve head, or any other protuberance. A difference of level of 0·34 mms. should be allowed for every dioptre of difference in the refraction.

With the indirect method, the procedure is somewhat different. Irregularities in the fundus are investigated by this method, by moving the convex lens to and fro in front of the eye, whilst concentrating the attention all the time on some fixed spot in the fundus, or on the optic disc. Should the disc be cupped, the edge will move to and fro in front of the floor of the cupping, "with" the movement of the convex lens. In the case of a protruding disc, it will be the apex of the projection that moves to and fro "with" the movement of the auxiliary lens. In other words, whatever plane is nearest to the observer, moves "with" the movement of a convex lens, and, as if in front of the more remote plane.

This method is known as parallactic displacement, and those who usually adhere only to the use of the direct method, may, with advantage, also make use of this parallactic or perspective displacement, for the discrimination of surface irregularities of the fundus.

With fair approximation, by moving the head to and fro towards the patient's eye, one can observe a similar displacement of all things lying in different planes. Even trifling differences of depth of surface can be noticed, such as is seen, for instance, in a case of perforation of the retinal membrane itself, as is shown in Plate 49.

There still remains for description, two other methods of examination, performed by using the ophthalmoscope, and which should be employed before using the methods which have already been described. They disclose to us opacities of the refractive media, whether in the cornea, the aqueous humour, the crystalline lens, or the vitreous body. If we illuminate an eye with a concave, or better still, a plane mirror, on looking through the perforation in the mirror, opacities are seen as dark shadows against a red glowing pupilliary reflex, since any returning rays from the illuminated fundus will be stopped by any such opacities, just an any opaque object (even if white in colour) would appear to be dark if held in front of some highly illuminated surface.

The whitish opacities due to grey lenticular cataract, can be seen very clearly in this way, better, in fact, than by any other means, and if one amplifies the method somewhat by making use, in addition, of a moderately strong lens of from plus 8·0 to plus 18·0, placed behind the sight-hole of the mirror, even the finest of opacities, either in or on the cornea, can be seen—such as for instance the most delicate of arterial branchings or the finest of precipitations, such as are deposited on the posterior surface of the cornea, in cases of iritis and cyclitis. It is necessary, of course, for the observed eye to be at such a distance, that the portion under examination, will be brought within the focal distance of the additional lens used with the ophthalmoscope.

In the same way, by means of transmitted light, vitreous opacities can be quite clearly examined, and it is better to always make use of a plane mirror for such a purpose.

While opacities in the cornea will apparently move in front of the pupil, if the observer moves from side to side, those in the lens will apparently move behind the pupil, and opacities in the vitreous will have a much greater relative movement, thus if the patient moves his eye rapidly from side to side—the opacities will apparently travel through an even wider arc, even after the eye has come to rest.

The Shadow Test, or Skiascopy.

This method of examination, called *Keratoscopy* by its discoverer, Lieutenant Cuignet, is also known as *Pupilloscopy*, or *Retinoscopy*, and is most satisfactorily performed with the assistance of a plane mirror. It provides the simplest possible way of estimating the refractive condition of an eye, and the technique is easily learnt. This shadow test is very highly recommended to all those who find a difficulty in measuring refractive errors, by the use of the direct method, in the manner which has been already described, especially in cases of astigmatism, and also to those who do not wish to make use of the Schmidt-Rimpler apparatus. The method must, however, be assiduously practised, and is not entirely without pitfalls.

Just as in the Schmidt-Rimpler method, with the shadow test one attempts to determine the position of the far point of the subject's eye, using, if necessary, a convex lens, which will bring it into a suitable position between the observer and the patient. This will be found to be specially necessary, in cases where there is a low degree of myopia and in hypermetropia. The far point should be brought to a position between 20 and 40 cms. from the subject's eye. When estimating a patient's refraction by this method, the fundus image is not used, but instead, the movement of an illuminated portion of the fundus is observed, while the mirror is tilted in various directions. The mirror illuminates a small area on the patient's fundus, and on looking through the peep-hole of the mirror, the observer can view any corresponding movements of this patch when tilting the mirror, by watching the pupilliary reflex.

It should be remembered that if a light source is placed to one side of a patient's head, and a beam is reflected into his eye by means of a plane mirror, the illuminated fundus patch will move from above downwards, if the mirror be tilted from above downwards, and, similarly, the movement will be from right to left when the mirror is similarly moved from right to left, this tilting of the mirror from right to left being, as if we wished to illuminate first the right and then the left eye of the patient. If the illuminated patch of retina, therefore, moves in the same direction as that in which the mirror is tilted, we may say the movement of the pupilliary reflex is " *with* " that of the mirror.

The illuminated area (or the surrounding shadow), cannot, however, be seen, in the patient's pupil, moving in the *same* direction as the tilt of the mirror, if the observer's eye is situated beyond the patient's far point. Such is the case in high degrees of myopia, since emergent rays from the subject's eye will converge to, and cross at, its far point, thus causing an inversion of the direction of movement.

In myopia, therefore, the shadow, or reflex, moves in a contrary direction to any movement of the mirror, (thus, it will move to the right when the mirror is tilted to the left). This is only found to be the case, however, if the amount of myopia is such that the distance of the patient's far point is less than the distance of the mirror from his eye. For example, if the mirror be held 50 cms. from the eye which is under examination, and the shadow still moves in the opposite direction, then the degree of myopia present must be more than 2·00 D. $\left(\frac{100}{50} = 2{\cdot}00 \text{ D.}\right)$.

Movement of the pupilliary reflex, in the same direction as the mirror movement, is restricted to the conditions where the observer is placed within the patient's far point, as in low degrees of myopia or emmetropia—or to cases of hypermetropia, where the far point lies behind the subject's head. In such cases, for example, the shadow movement will always be to the left, when the mirror is tilted to the left.

On the other hand, however, should the observer's eye be located exactly at the far point of the patient's eye, the illuminated patch will show no movement whatever on tilting the mirror, the pupil appearing alternately dark or bright. Such a position may be found by moving nearer to, or further away from, the patient, and when found, the distance apart of the two eyes should be carefully measured with a tape-measure, since this will give the value of the far point, and from it the amount of refractive error can be calculated, provided, of course, that the patient has not been accommodating. As an example—should the movement disappear when the distance of the observer's eye from that of the patient is 20 cms., the subject has myopia amounting to 5·00 D. $\left(\frac{100}{20} = 5{\cdot}00 \text{ D.}\right)$.

Should the pupilliary reflex move in the same direction as movements of the mirror, the observer must be within the patient's far point, and he can either recede from the subject, still moving the mirror from side to side, until all trace of movement disappears, or by placing a convex lens in front of the patient's eye, he can artificially bring the far point to within a measurable distance of about 30 or 40 cms. in front of the subject, in the manner already explained.

When choosing such an auxiliary lens, one point of importance should be carefully noted. Should the pupilliary reflex move rapidly, and "*with*" the movement of the mirror, and the edge of the reflex seems to have a flattened arc, then the case under consideration is either a low degree of myopia, or low hypermetropia. In such cases, a weak convex lens of about plus 3·00 D, should be chosen as the auxiliary. Should, however, the reflex move slowly, and the edge seem strongly concave, a case having a high degree of hyper-

metropia is being dealt with, and a stronger convex auxiliary lens will be necessary, and must, of course, be allowed for in the subsequent calculation. For example, supposing a plus 7·00 D lens brings the far point to 33 cms. from the patient's eye, then the case under consideration is not one of myopia of 3·00 D. $\left(\frac{100}{33} = 3{\cdot}00 \text{ D.}\right)$, but one with hypermetropia of 4·00 D, since quite evidently the apparent myopia of 3·00 D. has been artificially produced by 3·00 D. of the auxiliary lens, and the remaining 4·00 dioptres will move the far point to infinity, and thus correct the defect in the patient's refraction.

SKIASCOPY WITH THE CONCAVE MIRROR.

A concave mirror can also be used for the shadow test, but the movements of the pupilliary reflexes will then be exactly reversed, that is to say, the shadow will move "*with*" when the observer is beyond the far point of the subject's eye, and "*against*" if within that point, as in a case of hypermetropia. A convenient distance for observing the movements of the reflex is 1 metre, 20 cms away from the subject. If the shadow moves "*with*" the movement of the mirror, there will then be myopia of one or more dioptres. Concave lenses should be placed in front of the patient's eye until one has been found, which just reverses the direction of the movement of the shadow. This lens will have artificially moved the far point to more than 1 metre, (1 dioptre), in front of the patient's eye, and if the last lens with which the "*with*" movement of the reflex was observed was 'n D.', it would have measured the refractive error to within one dioptre. The patient's total myopia will, therefore, be n D.+1 D. Should the shadow move "*against*" the movement of the concave mirror, the subject either has myopia of less than 1 D, or is emmetropic or hypermetropic. In such cases, the error is corrected by placing convex lenses in front of the patient's eye until one gets reversal of the movement. If the lens required for this is n D, then the refractive error of the patient is n D.— 1 D.

The shadow test has its disadvantages. A wide pupil is advisable, and if this is too small, it should be dilated artificially. Even when the pupil is dilated, it is at times difficult to judge when movement of the reflex ceases or is exactly reversed. It is also not always possible to get a patient to totally relax his accommodation, since the mechanism of the test itself attracts his attention, causing him to fix relatively near objects. Further, the refraction is not always obtained at the macular region, but at some neighbouring area of the fundus.

Further descriptive details of the method will be found in Neustatter's "Grundriss der Theorie und Praxis der Schattenprobe (Skiaskopie) nebst Tafeln und Phantomen zur Skiaskopie," published by J. F. Lehmann at Munich in 1900.

(*Editorial Note.* For English students, reference is advised to the books on retinoscopy, published in America by J. P. Thorington and Edward Jackson. In these, detailed descriptions will be found of the application of the shadow test to the correction of astigmatism. In addition to the information given in these two books, it is to be recommended that in the actual practice of the method, when estimating astigmatic errors, some method akin to the "fogging system" used in subjective testing, should be employed. The examined eye should always have lenses placed in front of it, which artificially produce myopia in both meridians, and then by gradual reduction of the over-correction, the point of reversal is obtained, meanwhile the patient's accommodation will be kept in suspension. For the same reason, in such a case, the highest hypermetropic meridian or the least myopic meridian should be corrected first, and then concave cylinders *only* used for the correction of the other meridian at right angles).

The Choice of an Ophthalmoscope.

Before describing the method of procedure in ophthalmoscopic examination, some description of the instrument itself should be given. All types cannot, of course, be described in detail, that would need a volume in itself. Simple descriptions alone, without critical comment, would be of little help, whilst the comparison of the merits of the various forms would be unnecessary labour. After testing several of the best ophthalmoscopes in use up to the present time, one is, however, in the position of being able to judge their merits, although lack of acquaintance with some other types might cause some little injustice through lack of description. One type of instrument alone, therefore, shall be particularly mentioned, this being a small pattern, simple in design, introduced by myself for the use of my students twelve years ago, as a substitute for the Liebreich pattern, which, on account of several defects, proved to be unsuitable.

It will be sufficient to enunciate what principles are desirable in an ophthalmoscope, which are identical for all such instruments, and, as in the case of the microscope, are really quite simple. As in this latter instrument, the only variable factors are :—

(1) The mechanism.
(2) The quality of material and production.

The majority of large type instruments, usually called refraction-ophthalmoscopes, exhibit good workmanship, especially those produced by well-known instrument makers in different countries. It is always advisable, however, to test the accuracy of both mirrors and lenses and refuse to accept any which are defective. The mechanism of the instrument may be in accordance with the particular desires of an individual user, but it is important that the instrument should work smoothly and be easy to handle. The basic construction can be easily deduced from the description of the instrument which has already been given. With regard to the mirror itself, one which is concave is certainly necessary, and, from my own experience, an additional one which is plano is certainly advantageous. This plane mirror may, however, be dispensed with, or, if one is not supplied with the instrument, a substitute can easily be obtained by scraping a small portion of the "backing" off a suitable piece of ordinary plane mirror; this being especially useful for such purposes as the detailed examination of flocculi in the vitreous or for retinoscopy, although this latter can also be performed with a concave mirror. In my own opinion, the most suitable concave mirror is one with a focal distance of 14 to 17 cms., which serves equally well for both direct and indirect methods. When testing the focal length of the mirror, one should, at the same time, note if the reflected image is sharply defined, in order to judge if the surface grinding is accurate. Another point of importance is the size of the peep-hole, which should not be too small, or too little light is permitted to enter the observer's eye. This precaution is specially necessary when estimating refraction, when, on account of interposing auxiliary lenses and tilting the mirror, the observer is frequently at some considerable distance from the patient. The diameter should never be less than 3 mms. at the anterior, and should be a little wider at the posterior surface, so that the opening is rather larger at the back than at the front. Non-perforated mirrors are not recommended, and the interior walls of the perforation should be well blackened.

In those instruments designed for estimating refraction, it is requisite that the mirror should be capable of being tilted, if accurate results are desired, since one has to reflect a beam from a light source, situated at one side of the patient's head, into his eye, and the mirror will have to be tilted towards the light, as is shown in Figure A, the plane of the mirror (as seen from above), forming an angle with the plane of the patient. The observer will thus look obliquely through any lenses placed closely behind the mirror, and on so looking through any spherical lens, a cylindrical effect is induced, since rays will be refracted more in one direction, than if they had passed perpendicularly through the lens. Again, if the lenses are placed closely behind the mirror, the observer is further away from them than he should be. In the newest patterns, therefore, the mirror is so mounted, that it can be inclined at an

angle to the plate holding the battery of lenses, to either one side or the other, for use whether the light source is placed on the right or the left of the patient.

It is unnecessary to tilt the mirror with the indirect method, and correcting lenses are rarely required. Thus, ophthalmoscopes fitted with two mirrors, one for the indirect method, and the other for the direct, only allow of that intended for the direct examination, to be tilted. It is very occasionally necessary to use correcting lenses with the indirect method, as for example, when obtaining an enlarged image. It is advisable, therefore, to have a concave mirror of 16 cms. focal length, suitable for both methods, capable of being placed at an angle, and to use a small plane mirror for the examination of flocculi in the vitreous, and for retinoscopy. This need not be combined with the ophthalmoscope at all.

In discussing the mechanism of the instrument, the matter of primary importance is the positioning of the correcting lenses, behind the opening in the mirror. These should fit as close up to the mirror as possible, and it should be unnecessary to place too many, one on top of the other, as this decreases the amount of illumination of the image. When one is placed over another, the contact should be close, so that the observer's eye can still be as near as possible to the opening of the mirror.

The correcting lenses are generally fitted at the periphery of a circular plate, capable of rotation behind the mirror, so that the different lenses can be set exactly behind the opening, with the centre of the lens coinciding with the centre of the aperture, this being set by means of a series of catches. In some patterns, two such discs are placed, one over the other, so that the observer has to look through both, and in others, the discs are changeable, which is very troublesome. In ordinary practice, a simple disc proves quite satisfactory, if supplemented by a quadrant containing the very high power lenses, this rotating round the same centre. This quadrant can be turned out of position towards the handle, if not required, as in the pattern devised by Loring. Suppose the disc contains fifteen lenses—concave 1·0 D. to 8·0 D. and convex, 1·0 D. to 7·0 D, and an empty hole, and the quadrant contains concave, 16·0 D, 32·0 D, and 0·50 D, and convex, 16·0 D, by combining the disc with the quadrant, we have a range of lenses between concave, 1·0 D. to 40·0 D, and convex 1·0 D. to 23·0 D, a total of sixty-three numbers, and, in addition, the further values of half dioptres between 1·0 D. and 8·0 D. in concave, and 1·0 D. and 7·0 D. in convex. The provision of a second disc in place of the quadrant would, of course, considerably increase the total number of lenses available.

These correcting lenses should not be too small, the number in the disc being, therefore, limited. The diameter should not be less than 5 mms.

In conclusion, a short description of the condensing lens used in the indirect method is desirable, as too little consideration is devoted to it in many makes of ophthalmoscopes. It is better, for a beginner especially, to have one lens supplied, as large as the carrying case permits, rather than two smaller ones, because of the importance of the larger area of visible field, which will be secured. It is advisable also to always use the same lens, the strength of which should be 17·0 D, (focal length, 6cms.) and the diameter between 3·5 and 4·0 cms. The mounting should be such, that it will not be easily scratched if laid on a table, or soiled by one's fingers during use. It is also an advantage to have a short handle attached to the rim, for reasons that will be explained later. Should other convex lenses be required during indirect examination, in order to obtain increased magnification, a plus 13·0 D. or plus 14·0 D. from the test case may be used. With the larger instruments, the magnification of the inverted image may be increased by using convey lenses of between 2·0 D. and 4·0 D. behind the peep-hole, and, at the same time, going closer towards the patient.

The pattern of instrument recommended is one that can be used for the direct method, thus having a large number of correcting lenses so arranged, that they can be readily brought into position behind the mirror, as for instance, by means of the disc already described. In Liebreich's pattern, these lenses are placed one by one in a holder, which is very inconvenient, and they invariably get soiled. The changing of the lenses behind the mirror, should not necessitate removal of the instrument from the eye. As a general rule, very few lenses, not more than twelve, should be required, so the diameter of the disc need not be unduly large, and the price need not be unreasonable.

The Method of Conducting an Ophthalmoscopic Examination.

Ophthalmoscopy is best carried out in a darkened room with a moderately sized gas or oil flame. The electric incandescent lamp, on account of its small luminous filament, cannot be used conveniently, without special adaptation, though ophthalmoscopic lamps for electrical illumination have been devised by Deus, Eversbusch and others. H. Wolff devised an ophthalmoscope containing a tiny glow lamp. By the use of this instrument with the direct method, a large fundus picture can be seen and the retinal reflexes are very clear. If gas flames, such as the Auer lamp, are used, it must be remembered that the light is rather more greenish-white, and this will give different tints to the fundus picture, in comparison with more yellowish lights. The same remark applies to daylight also, if allowed to enter a darkened room through a suitable opening, and used for examination.

Patient and observer should sit opposite each other, some forty to sixty centimetres apart, with the illuminant on a table to the observer's right. The level of the light should be as nearly as possible that of the patient's eye. It is an advantage if the patient sits on a revolving stool, and the lamp should be capable of being raised and lowered at will.

Before commencing the ophthalmoscopy, it should be made a rule to always examine by means of *lateral* or *oblique illumination*. The habit of doing this, as it were " by second nature," should be cultivated. By this particular method, many changes can be observed that may have an important bearing on the ophthalmoscopic examination, therefore, it should never be neglected. For example, considerable time might be wasted by the indifferent observer, attempting to get a clear view of a fundus by the direct method, because he has failed to detect opacities in the cornea, or the lens, by omitting this examination by lateral illumination. The indirect method may be used much more successfully, in cases where there are opacities in the media—because the illumination is stronger and there is less magnification of the image.

For this examination, the light source should be placed to the right side of the subject, and by holding the condensing lens, which is supplied with the ophthalmoscope, to one side of the patient, a beam of light should be focussed on the anterior portions of his eye. By directing the focus of the beam of light passing through the lens, on to the different structures of the eye, the observer can examine them individually, using also, if desired, a good loupe, as further assistance.

After examination with lateral illumination, the light source should be placed a little behind and to one side of the patient, so that rays cannot proceed directly into his eyes. The lamp should stand quite near to the patient's head.

The second step in the routine examination, should consist of simple illumination of the eye. By thus reflecting light into the patient's eye with the mirror, so that the pupil glows with a red reflex, we can examine the eye by *transmitted light*, and this, as already stated, will disclose any opacities in cornea, lens or vitreous. For the discovery of such opacities at the peripheral portions of either lens or vitreous, the eye should be turned to various positions, the patient being directed to look up or down or sideways, the observer meanwhile keeping the light directed on the eye, so that the pupilliary reflex is always visible. Quite often, the presence of cataract has been diagnosed when entirely absent, because an observer has failed to examine by means of transmitted light, and has mistaken a greyish pupilliary reflex for cataract, which is entirely unconnected with that condition.

By means of this method of examination, by moving the mirror, the beam of light, as in Skiascopy, can be directed through the pupil in all directions, so that certain anomalies can be observed, such as Keratoconus or Lenticonus—which are shown by a peculiar type of shadow ring (or part of a shadow ring) in the pupilliary area. One can also detect any inequalities in the corneal surface, (through scars or ulcers), when little spots of shadow can be perceived, and the position of the obstacle to the path of the light rays can be localised, after some experience.

The method with which the finer changes can be detected by the introduction of a supplementary convex lens behind the mirror and using transmitted light have already been discussed (see pp. 28 and 29).

The third step in routine examination should be the use of the *indirect method*, since this permits of a general view of the whole fundus area. For this purpose, a convex lens of 17·0 D. should be held about 6 cms. in front of the patient's eye, and the lens should be supplied with a handle, so that the observer's hand and fingers will not unnecessarily obscure the patient, or attract, the attention of the patient's other eye. Such a handle is often quite an advantage, since this other eye of the patient should be used to fix the direction of vision, while he relaxes accommodation by gazing at some distant object. For the examination of the left eye, the patient should be asked to look past the surgeon's left ear, and to permit of him doing this, his right eye should not at any time be covered. The beam of light should now be directed into the eye, through the supplementary or condensing lens, and the observer on looking through the peephole, if lens and mirror are in the requisite positions, should

immediately perceive the disc area of the patient's left eye. Whilst conducting this examination, the observer should accommodate for a plane somewhere between the ophthalmoscope and the supplementary lens, which will correspond to the position of the fundus image, as has been previously explained. (Ref. Fig. F.) This is usually found to be one of the difficulties of the method, the beginner naturally accommodating, either for the subject's eye or the condensing lens, and so cannot get a distinct view of the fundus image, which is formed, somewhere between his own eye and the condensing lens.

To remedy this disability, practice can be recommended with the same condensing lens on fundus pictures, such as are published in the present volume. These should be placed some 60 cms. away, and examined with the condensing lens of plus 17·0 D. held some 20 cms. away from the picture. At the same time, one can learn the effect of variations of position from the inverted image. By such practice, experience can be gained in overcoming another drawback to the indirect method, namely, the reflexes on the surfaces of the condensing lens. By holding the lens somewhat obliquely, one can manage to look between these reflexes, and having learnt to obviate them, it will be found to be all the easier, to overcome and ignore the corneal reflex, which also causes some disturbance during the examination.

When skilled in seeing the inverted image with the living subject, the observer should next cultivate the habit of keeping the patient's other eye under observation by direct vision—so as to keep its direction of gaze under control. Children frequently disregard instructions to look in one particular direction, and thus will frequently not be looking at the observer's left ear, if he wishes to examine the child's left disc. For the avoidance of any waste of time, the observer should insist on the patient maintaining one direction of vision for some time, but after asking the subject to fix, say, the observer's left ear, he should take care not to make it an impossibility for him to do so, by covering the subject's other eye with the hand holding the condensing lens. This hand should be rested against the patient's face so that this other eye will not be covered at all—nor will his view of the distant object selected for fixation, be obstructed in any way.

The observer should also get into the habit of raising the patient's upper lid, with one of the fingers of the hand holding the condensing lens; this being especially necessary when looking at a portion of the fundus, while the subject is looking downwards, or when examining a patient lying in bed. This can easily be done by pressing lightly on the upper lid, with the ulnar side of the fourth finger, and drawing it slightly upwards. It is not sufficient to inspect the disc alone and its immediate surroundings, but there should be systematic examination of even the peripheral portions of the fundus, and to enable this

to be done, the patient should be asked to look up and down, and to the right and left. In order to see the patient's right disc area, he should be instructed to look immediately past the observer's right ear at the wall of the room, since the position of the disc is about 15° to the nasal side of the posterior pole of the eye. This is probably the most important, and at the same time, the most difficult area of examination, because the most essential portion of the retina is being viewed. Some considerable practice is required to examine this area thoroughly, because the corneal reflex is rather annoying, the pupil tends to contract on account of the incident beam entering the eye perpendicularly, and, in addition, the image will be weakly illuminated. To examine the left macula, the patient should be instructed to look into the observer's left eye. The observer should then get the image of the left optic disc in front of the temporal quadrant of the condensing lens, and by turning the ophthalmoscopic mirror towards the nose, the macular area should be seen, in front of the nasal portion of the condensing lens, and the disturbing corneal reflex will disappear towards the temporal side. To inspect the macular area of the right eye, he should be asked to look towards the observer's right ear, and the same procedure repeated. Care should be taken that no light falls into the fellow eye, thus avoiding unnecessary contraction of the pupil, and in the case of very small pupils, these should be artificially dilated by the methods already described.

When using this method, it is of the utmost importance that the condensing lens should be perfectly clean and quite free from scratches. The beginner's attention is always attracted to imperfections in the lens, making it difficult for him to see the fundus image, and, additionally, they may be interpreted as some abnormality in the fundus itself, so that, apparently, something is seen, which in reality does not exist. Even the minute spots, which a finger leaves on the glass, appear white on the fundus picture, and may look like whitish spots on the retina, such as are seen in cases of Albuminuria and Diabetes. When the fundus has been sufficiently examined by the indirect method, the observer should then proceed to the fourth stage of the examination, which is, inspection by means of the *direct method*. This is best done by placing the light close to the patient's head, and on the same side as the eye which is to be examined. The beginner should practise on the patient's right eye, most people finding this to be the easier of the two, and inspect this with his own right eye. The patient would then be seated with the light source on his right hand side, and a beam is reflected into the eye. Keeping the pupil illuminated, the observer should then approach nearer and nearer, ultimately getting as close as possible, until such details as portions of blood vessels in the fundus can be seen in the reddish glare of the pupil, making sure, as already explained, that his own accommodation is held in suspense. The observer

should imagine that he is looking beyond the patient's head into infinity. The patient should also be told to look ahead and slightly to his left, (into infinity), and then the observer should be able to pick out the disc, by tracing the path of blood vessels back to it. Examination of the left eye is rather more difficult, since it should be examined with the left eye, to avoid collision between the noses of the two persons, or the patient must turn his head away somewhat, and thereby lose some illumination. It is certainly better if from the very first, one gets into the habit of examining a patient's right eye with the right eye, and the patient's left eye with the left.

Facility in observing the erect image will be simplified, if the following procedure is observed. The light should be reflected on to the patient, by means of a concave mirror held about 5 cms. from his eye, (with a plane mirror from six to ten centimetres), and on looking through the peep-hole, an illuminated area will be seen with a dark blurred spot in the centre, corresponding to the image of the hole itself. This can easily be seen if the light is reflected on to the patient's forehead. It will be noticed that the patient's pupil will appear to be illuminated with a red glow, if this image of the mirror opening be made to coincide with it, so that if this position of the dark spot be maintained as we approach nearer to the eye, (of course without accommodating), the spot will get more distinct, and the pupil will continue to glow redly, and at length, some part of the fundus will become visible, when a suitable position has been finally reached, and the refracting media of the eye produces a sharply defined image. Thus, it is not sufficient, when using the direct method, to merely reflect light with the mirror into the patient's eye, but the centre of the mirror, or, in other words, the peephole of the mirror, must coincide with the patient's pupil, otherwise no rays emerging from the patient's eye, could enter the observer's eye.

It is noticeably better, if correcting lenses are required, that these should be placed into position without removing the mirror from the eye, and it is, therefore, advantageous to turn the disc of lenses provided. In this way, the observer will be assisted in keeping his accommodative power relaxed.

It is certainly good practice to commence ophthalmoscopy on a rabbit, and the picture of a rabbit's optic disc and surrounding area will be found to be included, amongst the plates in this book. (Ref. Fig. 6a). A rabbit's pupil is naturally widely dilated, and the eye is usually immobile ; in addition, such eyes are invariably hypermetropic, the emergent rays are, therefore, divergent, so that it is a simpler task to obtain a direct image.

Should a plane or a concave mirror be used for the direct method ? This question is answered by the statement that both types of mirror have their advantages. With one or the other of them, facility should be gained in

carefully noting all fundus changes, especially in matters of hue and tint, and particularly in the appearance of the disc. Abnormal colour changes, such as pallor of the optic nerve or grey discolouration, cannot be seen any better with a plane than with a concave mirror, and if the two are used, there may be some little disadvantage in discriminating the recognition of one set of abnormal colourings, for each type of mirror. By using one type of mirror only, a student should gain greater proficiency in diagnosis. It is certainly better, to always use the same type of mirror for the direct method. In my own opinion, examination of the macular area is more thorough if the concave mirror is used, since any alterations that may be present, are seen much better than with a plane mirror, because while studying this area of the fundus, the pupil contracts, and, in addition, owing to the darker pigmentation of this region, the image is dark enough even with a concave mirror, and much too dark and indistinct when a plane mirror is used.

The Normal Fundus.

It has been already emphasised that the appearance of the normal fundus picture has so many variations, that it is a matter of the utmost importance, that there should be the fullest possible acquaintance with the various phases of normality, before the student investigates pathological changes.

The beginner cannot be too strongly advised to study normal cases, both assiduously and frequently.

A sound knowledge of the detailed anatomy of the several structures is, of course, of extreme, importance for fully appreciating what are normal conditions in the fundus appearance. Figures 2, 3, and 14 have been inserted for this purpose. The first question that will naturally be asked, will be as to the cause of the red colour of the fundus reflex—which is sometimes erroneously described as "abnormally red." The reason for this is, that the choroid is a structure consisting very largely of blood vessels, especially the uppermost layer, which is nearest to the retina and called the "plexus of the chorio-capillaris," and which becomes denser as we get nearer to the posterior pole of the globe. The red colour of the blood in these vessels is the cause of the red colour of the fundus reflex. To a small extent it is also caused by the colour of the retinal vessels, though these are quite a minor consideration. The purple colour of the optic disc is an even less important factor, for it cannot be discriminated, as such, any more easily than a pale rose tint could be detected on a background of deeper red, and, in addition, this purple colour of the disc is very pale, and disappears entirely, when brightly illuminated. The typical colour of the fundus varies quite a lot in shade or hue. With some it is more a yellowish red, and with others, a dark red or even a brownish red. This is due to variations in the pigmentation of different eyes. Generally speaking, dark haired people will have a darker fundus colour than blondes. Again there may be differences in distribution of the pigment. For example if the epithelial layer of the retina is very strongly pigmented, then the more uniform will the retinal reflex seem. The red colour of the choroid will at the same time be more or less obscured and the choroidal vessels will be invisible. In other cases the pigmentation may be strongest in the choroid, especially in the spaces between the vessels, and the epithelial layer of the retina, by contrast, may be only sparsely pigmented. The choroidal vessels, also, do not show with equal clarity behind the retinal vessels, so much so, that in many persons, only darker areas may be discerned, which, on closer inspection, prove to be the intervascular spaces in the choroid, (Figures 1, 6a, 9a, 22, etc.) whilst in other people, the whole system of choroidal vessels may be readily perceived, on account of the presence of much

pigment in the spaces between them. Where there is a lack of pigment in both retina and choroid, as is the case in albinos, the choroidal vessels seem red on a lightish background (Figure 10b). This latter is a reflex from the white sclera. In such persons as blondes, having very little pigment, and yet not being albinos, the choroidal vessels are sometimes seen as reddish lines on a lighter red background (Figure 4).

With regard to the pigmentation of this background, it should always be remembered that the area surrounding the posterior pole of the globe, which corresponds to the macular region and the neighbourhood of the disc, is normally darker than the more peripheral portions of the fundus (Figure 1 and many other pictures). The darkish red brown spot seen in the middle of the macula, is the result of some thinning of the retinal membrane at this position (refer Figure 14). The choroid behind the pigmented epithelium area is therefore more clearly seen at this spot. The choroid seems to be darkest at the point where it edges the optic disc, enabling us often to see more or less clearly a well-defined black ring, which is often called "the choroidal ring" (Figure 1 and 4, etc.) If the choroid does not encircle the optic nerve, but there is a clear space between the edge of the disc and the margin of the choroid, there will be seen a more or less complete white ring, on account of the sclera becoming visible in the gap, between nerve and choroid, and this white ring is known as a scleral ring (Figures 1 and 4, etc.). The optic nerve material, as seen by the ophthalmoscope, seems rather greyish red, and partially transparent, the nasal half being somewhat darker and the temporal half rather lighter. This is accounted for, by the fact, that the nerve fibres are more densely packed, and more emerge from the nasal portion than from the temporal. The centre of the disc is often the lightest portion, but not invariably so. This is in consequence of the presence or absence of a more or less strongly defined excavation, (Figure 2a). The deeper this is, the more clearly is the lamina cribrosa seen, and the lighter will this central area appear. The disc of a rabbit shows this excavation very clearly (Figure 6a). One can quite clearly distinguish how the retinal vessels, emerging from this crater-like cup, branch out over the whole retina. Such a deep excavation, where the lamina cribrosa is visible at the base, is called a *physiological cupping* (see Figures 5b, 48/4, and 54b). The lamina cribrosa is shown as a greyish stippling at the floor of the excavation. The lip of the physiological cupping is in the form of a fine edge, over which the retinal vessels turn, as they dip down into the excavation.

The disc is not always perfectly round ; it may as a matter of normality be slightly oval, either horizontally or vertically. Normally, it does not project beyond the plane of the retina, or if it does, only to a very slight extent

on the nasal side, for one third of its circumference, and it is, therefore, more correct to always refer to it as the optic disc (which is the usual English term), rather than as the papilla.

The retina (apart from the layer of pigmented epithelium) is transparent, and on this account, it is almost impossible to see it with the ophthalmoscope. Now and again one can see round about the disc, usually just above and below it, a faint striation of nerve fibres. Much oftener in young people with dark pigmentation, it is possible to see a greyish kind of veil, where the retina is thickest, that is, round about the optic disc and the foveal region, and generally in such persons the fundus picture in these places seems leaden grey rather than red. In such individuals, especially when they are young, one can also see, almost invariably, rather strongly marked retinal reflexes, especially from the regions of the optic nerve and the fovea centralis. These reflexes show as grey-white spots, irregularly shaped patches between the blood vessels, or as bright lines alongside the vessels, and quite often (even in older cases), as a ring around the fovea centralis (see Figure 5a), or as a small ring or a small bright sickle in the middle of the fovea itself. These bright spots are recognised as reflexes, because their shape and position vary with movements of the mirror, and they also possess a characteristic sheen. They seem most noticeable during examination by the indirect method, if the pupil is not too wide.

The most strongly marked reflex is seen round about the fovea centralis, and often if the macula is not directly examined, only a half-moon shaped portion, which is in the nasal half, is first visible. Should the entire reflex be seen, it generally appears as an oval, whose long diameter is horizontal, and with a vertical diameter approximately equivalent to that of the optic disc. Towards the centre of the fovea, it is sharply defined, but it gradually fades towards the margins. Now and again, one sees this reflex quite circular. The oval shape cannot, as JOHNSON suggests, arise from some distortion (on account of the lamp standing sideways, etc.), but it is due to the fovea itself being slightly oval in the majority of cases. In any well marked oval reflex of this type, it will be found that if the light is held over the patient's head, there is no alteration in the shape of the oval. Within the macular reflex, the appearance is usually quite dark—the colour being deepest in the middle, where there are no reflexes, with the exception of an exceedingly small point reflex in the centre, which is surrounded by a dark foveal spot. (Refer Figures 1 and 5a).

To thoroughly examine the macula, the stronger magnification of the direct method is essential. One can then see that the central reflex point is formed by a small shining sickle, and, according to the movements of the observer's head, so will the horns of this sickle seem to move round the middle point of

the fovea. Should the observer look into the eye along the nasal margin of the corneal reflex—so will the sickle be seen, with the horns directed to the temporal side, whilst, if he inspects along the temporal margin of the corneal reflex, they will point to the nasal side. If the observer can manage to get a direct view along the axis (into the fovea itself), that is to say, straight through the corneal reflex, the sickle will change to a small ring of about the same diameter of one of the main vein trunks, as seen on the disc, in some cases varying slightly larger or smaller than this vessel. The bright corneal reflex is very aggravating during such an examination, however, since it is positioned immediately in front of the centre of the macula. In eyes that are not too strongly pigmented, one can see in the macular area, especially at the centre, in the neighbourhood of the rather dark foveal patch, a fine dotting of the background, as if a mosaic of minute light and dark spots had been laid down. This is nothing more, however, than lack of regularity in the pigmentation of the epithelial layer of the retina. If the pigmentation of the eye is strongly defined, this mottling may be seen more or less over the whole fundus area.

Dimmer,* who has made a special study of light reflexes on the anterior surface of the retina, has shown that the small foveal reflex is the result of regular reflection at the most central, and, therefore, the deepest part of the foveal pit, and is actually the inverted image of the sickle, or ring-shaped portion of the mirror, adjacent to the peephole. The centre of the foveal pit itself, acts as a small concave mirror (Ref. Figures 14a and c), which will reflect light rays, so that they will emerge again, through the subject's pupil. Rays, however, which are reflected back from the very edge of this pit, (from the periphery of the foveal depression), cannot emerge through the pupil, and therefore no reflexes are observed in the remaining portion of the fovea, which accordingly seems dim, (though now and again an additional rather larger luminous ring can be observed, concentric with the foveal reflex). Outside the actual rim of the foveal pit, the light rays are so reflected that they can emerge from the pupil, and so, from here, the well defined reflex of the macular ring, which has already been mentioned, can be seen. The somewhat sharply defined inner edge of this oval indicates the position, therefore, where the retinal substance commences to thin out, and so form the foveal pit, and where the sides of the depression commence. The macular reflex must, therefore, coincide exactly with the fovea centralis, and we can, thus, judge the size of the latter with fair exactitude. Since the optic disc has, in average cases, a diameter of 1·5 mms., the vertical diameter of the fovea is approximately just the same, the horizontal diameter being rather more, ignoring, of course, outstanding individual exceptions both here and in the dimensions of the disc itself. In the direct method with an ordinary concave

* Dimmer "Die Ophthalmoscopischen Lichtreflexe der Netzhaut," 1891.

mirror, we see the macular reflex very faintly, or not at all, on account of so little light actually illuminating the fundus with this method. It is seen more clearly, if a stronger concave mirror is used (for example, one of 8 cms. focal length).

In similar fashion to the macular reflex, there are formed other retinal reflexes, particularly those alongside the blood vessels (see Figure 5a). From DIMMER'S researches (*loc. cit.*) we find these are the result of concave cylinder or sphero-concave areas, which exist on the inner surface of the retina. These surfaces reflect back, at certain fixed distances, inverted images of those portions of the ophthalmoscopic mirror from which light is reaching them.

In the examination of the retina, our attention is next drawn to the retinal vessels. The first point to be noticed, is, that all of them unite on the optic disc, since the entire blood supply of the retina is received from the central retinal artery, and which, with the central retinal vein, (by which the venous blood flows from the retina), lies in the centre of the axis of the optic nerve, as it enters the globe. The artery divides into its various branches at the disc, or (in certain instances), even before it reaches it, and the vein does the same. Arteries are distinguished in the fundus picture because they have a rather lighter colour than the veins, and the central stripe also seems brighter and rather broader. Such differences in colour are, however, only noticeable in the larger branches, and also the reflexes are more strongly marked in the case of the thicker vessels, if the stronger magnification of the direct method is made use of. The bright stripe along the axis of the vessel in the arteries, according to DIMMER, (*loc. cit.*) is due to reflection of the light rays by blood corpuscules in the axial stream, and in the veins, to a similar reflection from the anterior surface of the blood column. This central stripe in the arteries is reddish, therefore, whilst that of the veins is white, being a direct reflection. †

Generally speaking, the path of the arteries is straighter than that of the veins. The central artery, and also the central vein, divides into a variable number of branches in the final portion of the optic nerve, or in the excavation, or upon the optic disc. The chief of these branches in both artery and vein runs directly upwards and downwards, but quickly subdivide once more, so that one can define an inferior, and superior, temporal artery and vein. In most cases a nasal branch of the artery and vein can be made out—conveying

† For technical reasons it has not been possible to reproduce these reflexes of the vessels with exactitude in the illustrations in this book, especially in the way of both width and colour, and in addition, it should be remembered that the small degree of magnification of the indirect method does not make the reflexes at all clear and distinct.

blood to and from the nasal section of the retina. The important macular area is partly supplied by vessels running directly from the disc, and partly by branchings from both the inferior and the superior temporal artery and vein, which surround the macula in a series of arcs. For this reason, at the macula and its immediate neighbourhood, we generally see only very delicate vessels, running more or less directly towards the centre, though it is impossible, even with the direct method, to trace them to the centre of the fovea. Usually they disappear from view near to the inner edge of the macular reflex. They do, however, reach the actual foveal centre, as is proved by the well known entoptic Purkinje Figures (reproduced by moving a fine opening in front of the eye, or moving to and fro a small candle flame in a dark room).

At the periphery of the retina, the number of the retinal vessels is small; they are more attenuated and they are generally situated radially. Departures from normal arrangement of the vessels can be observed in the following cases:—

(1) If a so-called cilio-retinal vessel is present. In such cases, a very fine artery appears at the temporal edge of the disc, which has its origin in the choroid, passes through the neighbourhood of the disc and enters the retina, where it travels, more or less straight, towards the macula. Such a condition is not rare, and when seen, is found to occur in both eyes.

(2) If an opticociliary vessel is present, which is much rarer. In these cases, a branch of the central retinal vein (or central retinal artery), does not travel as far as the retina, but disappears at the edge of the disc. In other words, it betakes itself into the plexus of choroidal vessels.

(3) Instead of, as is usual, the venous flow from the choroid being by the way of the vortex veins at the equator of the globe, (Figure 10b), one may see in darkly pigmented eyes, especially if strongly myopic, posterior vortex veins, having similar, but less noticeable ramifications, bearing away choroidal blood at the edge of the disc (Figure 86). Why such posterior vortex veins are found so often in cases of high myopia is not at all clear.

Pulsation Phenomena.

One other feature seen in the fundus, deserves full consideration. When the blood vessels of the retina with their manifold ramifications are seen for the first time, the question arises as to why they seem so stiff and immobile, and show no signs of pulsation, with the exception of an occasional, and not always observable, beat at one or more of the vein extremities on the optic disc. The reason why no really distinct, or only extremely slight pulsations of the retinal arteries can be usually seen, lies in the fact that, these vessels are of such small calibre that little or no pulsation can be evident, because the pulse wave has become too weak before it reaches so small an artery. A factor that must not be overlooked also, is that the fundus is seen with the ophthalmoscope very much magnified, and if it were examined with the naked eye, we could only see the retinal arteries, even where they are widest, (that is, on the disc itself), as very fine red lines.

A second reason for this weak pulsation of the retinal arteries, is supplied by the intra-ocular pressure, under which these function. This will counteract the pulse wave. It is possible, however, with very careful attention, to observe real pulsation movements in the retinal arteries of normal persons, but only when the path of these arteries is curved. After a large number of very detailed examinations, I have formed the opinion that if one of the larger retinal arteries is distinctly curved, (and also in the neighbourhood of the optic disc) a pulsation movement is always evident, especially as a bulging of the bow synchronising somewhat with the systole, and also, at the mid-point of the arc, there is some to and fro movement at right angles to the chord of the arc. With two successive bows giving an "S" shaped formation, the phenomena is even more noticeable. It is also clearly manifested if the action of the heart is strong. This pulsation is more easily and often seen, than is the actual pulsation increase in calibre, or, in other words, alternating expansion and contraction of the vessels themselves. This may be seen in cases of heart disease. Another type of movement namely, a pulsatory backward and forward motion of the larger branches of the arteries at the point of bifurcation, can also be clearly seen in cases of heart disease.

Even in normal cases, however, a type of artificial pulsation can be produced, which can best be described as an intermittent influx. This is done whilst examining the disc, by exerting, with the finger, a gradually increasing pressure upon the eye under examination, when the ebb and flow pulsation of the blood column, in the ends of the arteries on the disc, is quite evident. This phenomenon can be observed even with the indirect method, but, like all pulsation in the fundus, it is best seen with the direct method.

By this same method, one can also observe how the intermittent influx is brought about. As soon as a certain pressure is produced by the finger, the arterial ends on the retina are emptied, and at the same moment, one can see that only at the crest of the pulse wave is any blood forced into the vessels, and the vessel then collapses until the succeeding cardiac systole, so that these ends of the arteries are consequently empty during the intervals. The ends of the veins naturally exhibit no such pulsation ; on the contrary, should there be any physiological venous pulsation, as a rule, it will instantly subside with the decrease in the contents of the vein ends, the pulsation reappearing again when pressure on the eye is removed, when the ends of the veins will once again dilate, and even finer vessels on the disc will seem fuller and stand out more clearly than before the application of pressure on the eye. The intermittent influx of arterial supply to the vascular system of the retina, is also evident without any finger pressure, if the internal tension of the globe is increased by disease, as in that type of glaucoma, for instance, where increase in pressure is rapid (acute glaucoma), though it is less noticeable in simple glaucoma where there is a slower increase in pressure. The intermittent influx is then seen in exactly the same way as when pressure is artificially applied. The pulse wave, only at the moment of its greatest height, is able to overcome the pressure on the walls of the vessels.

The same kind of thing would happen if pressure were exerted on the central retinal artery at the back of the globe, as for instance, if there were a growth. Similarly to this arterial end pulsation, there is a venous end pulsation, better described as an intermittent efflux. This phenomenon is rather more difficult to explain. It has already been pointed out that a pulsating movement, having no significance, can often be seen in normal eyes. There are three explanations already given. Donders (1) suggests that during the cardiac systole, the arterial pressure in the globe is raised somewhat, and the ends of the veins on the disc will then be compressed, because lateral blood pressure is least marked in them. Immediately the cardiac systole is over, the venous blood flows away. Helfreich (2) gives another explanation consequent on investigations made by Bergmann and Cramer ; it can be assumed that on account of the rhythmical increase in the quantity of blood sent to the arteries of the brain, it is forced by compression out of the cerebral veins and, therefore, causes a pulsation marked change in the rate of flow of the venous blood from the cranium. There are found to be noticeable pressure variations in the venous sinuses of the brain. Any pressure variations in the cavernous sinus, will necessarily influence blood movements in the veins of both the orbit and the globe. If the pressure diminishes in

(1) **Donders.** Archiv. f. Ophth., Vol. I.
(2) **Helfreich,** Archiv. f. Ophth., Vol. XXVIII.

the cavernous sinus, the cerebral blood is, consequently, siphoned off, with a reduction in the calibre and more or less collapse of the veins, if the walls of the vessels are so lightly attached to surrounding tissues, as to permit of such collapse. In any case, certain definite conditions must prevail for the pulse to show itself, otherwise, it would always be evident.

Either of these theories can be used for the explanation of the venous end pulsation. That there is a slight increase in the internal pressure of the eye, coincident with the cardiac systole, has been demonstrated by Von Schullen amongst others, by means of the manometer. The fact that, a slight increase in pressure, as with the finger, immediately diminishes the amount of blood in the vein ends on the disc, is quite evident to anyone with the ophthalmoscope. The slightest rhythmical pressure with the finger is sufficient to stimulate the venous pulse. On the other hand, it is plausible (according to Helfreich), to assume that during the cardiac diastole, there will be an increase in the rate of blood flow from the orbital veins into the cavernous sinus. If this increase is so strong, that, as a consequence, the veins on the disc will collapse, (as is the opinion of Helfreich), is a matter of dispute. It can be much more easily assumed that since the blood pressure in these veins is certainly very low at the end of the cardiac diastole, and that an increase in the intra-ocular pressure with the cardiac systole, (Donders) causing momentary contraction of the veins, or even collapse, by holding back the venous blood from the brain, (Helfreich) will neutralise their contraction, and so produces some dilation of the vein ends, which, no one denies, shows itself immediately after the cardiac systole. In this way, the actual data used in both of the theories is utilised. Further investigation may show if such an explanation is correct.

There is yet a third explanation of this venous pulsation put forward by S. Turk (1), who suggests that it is due to a continuation of the arterial pulse wave, through the capillaries into the veins--a kind of progressive venous pulsation—the dilation being a consequence of the cardiac systole, as in the arteries. The abnormal prolongation of the pulse wave, he suggests, is facilitated by the relatively high extra-vascular pressure to which the blood vessels in the eye are subjected.

A true arterial pulsation is clearly seen in cases of aortic insufficiency: In such cases, the difference in the blood pressure in the arterial system during systole and diastole, is abnormally great; that is to say, on account of cardiac hypertrophy, the pulse beat is abnormally high and followed by an abnormally low depression, since the blood flows back to the heart through the insufficient valve (if the aortal passage is not too narrowed). The smaller arteries, therefore and even the capillaries pulsate in this disease, and, in typical cases, one can

(1) Turk. Archiv. f. Ophth., Vol. XLVIII., p. 3, 1899.

see not only considerable pulsation of the retinal arteries and veins, but also a pulsating reddening and blanching of the papilla. The main arterial branches exhibit a true pulsation, both by variations in calibre and in actual movement, and this is seen some distance away from the disc. The veins also show characteristic pulsation (by changes in the calibre) in such cases, often in a much more marked degree than in the arteries. If, however, there is little insufficiency and practically no hypertrophy of the left ventricle, or if the heart action is only weak (as when resting), this pulsation of the vessels will disappear, and only become manifest again if the patient increases his heart action. The phenomenon is also less noticeable if, at the same time, there is aortic stenosis. When other forms of heart disease occur, practically no pulsation phenomena of the retinal vessels can be observed. Now and again in mitral insufficiency, an arterial pulsation occurs, and in mitral stenosis, I have only seen it once in fifteen cases, whilst in mitral stenosis complicated with aortic insufficiency, it was seen in one case, but not at all in a second. Even in stenosis of the mitral valve, and in insufficiency with stenosis of this same valve, no pulsation signs were evident, as could only be expected.

Thus, pulsation phenomena in the fundus picture, are of very little value for the diagnosis of cardiac disease. In addition, the actual observation of pulsation with the ophthalmoscope is extremely difficult. If it is desired to study them carefully, the patient should not be in bed, but seated on a chair with his arm resting on a table. The observer also should, whenever possible be seated, with his arm that is holding the mirror, supported on a table. The pulsation movements of his own arm, or trunk, will not then be mistaken for similar pulsation movements in the vessels under observation in the patient's eye. Pulsatory movements in the patient's trunk can also be falsely interpreted, and auto-suggestion also affects the examination. If one anxiously desires to see pulsation, evidences of movement will be apparently seen, when, in reality, not the slightest trace of pulsation exists. As will be quite evident, these phenomena are only to be observed when examining by means of the direct method.

Modern Developments in Ophthalmoscopy.*

The Use of Self-Luminous Instruments.

For many years now, various patterns of self-luminous ophthalmoscopes have been available, and have now come into general use. These can either be supplied with a dry battery which is fitted into the handle, or can be connected up to an accumulator or large capacity dry cell. The light source is a small electric glow lamp, and a variable rheostat is fitted so that the intensity of the illumination can be varied. In the better designed instruments, this glow-lamp is covered with a supplementary cap, containing a very strong condensing lens of similar diameter to the lamp, so that if the filaments are situated as nearly as possible at the posterior focus of this condensing lens, the transmitted beam, projected along the tubular portion of the instrument, will be as nearly parallel as possible, and a minimum of light rays will be lost by "scattering." The exit end of the tube is also fitted with a second lens, so that requisite convergence can be given to the exigent beam. By means of a suitable mechanical arrangement the distançe of separation of the light filament from this second lens, can be varied, so that the degree of convergence of the exit beam is also variable. Just above the converging lens a mirror is inclined at 45°, so that the beam is reflected through a right angle, and a narrow slit, in this mirror, lying just in front of the peep-hole of the ophthalmoscope head, permits of observation along the axis of this reflected beam.

Behind the peep-hole, the customary arrangement of supplementary lenses can be positioned, by similar mechanism to that used in the earlier types of instruments, which have already been described. In certain instruments incorporating the May patent, a refracting prism is used, instead of a plane mirror, to reflect the beam through a right angle. In the majority of instruments so fitted, however, the peep-hole is placed above the edge of the prism, in such a way, that the observer does not look directly along the beam of light, but in a direction somewhat oblique to the axis of the beam. In such cases, the fundus picture is not evenly illuminated, but shows a considerable crescent shaped area of apparent half shadow.

* This remaining section is not included in Dr. HAAB'S original treatise, but has been added with the intention of explaining some of the more recent developments in Ophthalmoscopy, which have been made, since the issue of previous English editions of the Work.

Some of these luminous instruments are now fitted with "red-free" filter screens either interposed in the projected beam, or fitted in the disc of supplementary lenses, but as there are fixed limits to the possible intensity of the light source—such filter screens are not usually entirely red free, otherwise the illumination of the fundus picture would be too weak.

The self-luminous pattern of instrument possesses obvious advantages. It can be used almost anywhere, and under almost any conditions, and is quite self-contained, being independent of any extraneous light source. In the direct method of examination, they entirely do away with all the difficulties of awkward "positioning," so as to reflect a beam into the subject's eye.

THE USE OF RED FREE SCREENS.

By far the most important development in ophthalmoscopy in recent years, has been the use of filter screens, which absorb the red rays of the fundus reflex. A very detailed description of the apparatus required and the technique of this method of examination has been given by Professor Alfred Vogt, in his "Ophthalmoscopy in Red Free Light," describing his experience, with its use, since 1912. He points out, that when the fundus is seen under these conditions, the macular region is shown up, in its characteristic yellow colour, thereby making it possible for this area to be carefully studied, whereas by ordinary illumination it cannot, as a general rule, even be localised. The path of the nerve fibres, and any changes which may be occurring, are much more clearly visible, and any inequalities of the anterior surface of the retina, in the form of folds or pleats, are indicated by reflexes, which would only be seen with the greatest difficulty, if at all, under ordinary light. In the same way, opacities in the media, changes in the walls of the vessels and other retinal degenerations, show up much more clearly in red free light, and the smaller vessels stand out better, being seen black on a light green ground, instead of red on a red background. For detailed inspection, the apparatus essentially consists of a powerful light source (generally an arc lamp), and the beam is passed through a solution of copper sulphate, or erio-viridin, by which means, perfectly red free light is obtained. With such illumination, details even of the macular area are clearly visible, and since the chief value of the improvement is an ability to recognise and study fine detail, the direct, rather than the indirect method is invariably employed.

For ordinary examination, however, such precise methods are not necessary, and several self-luminous instruments are now obtainable with filter screens which are much more translucent than those mentioned above, and there is not, therefore, the same necessity for such enormous increase in the intensity

of the light source. These screens are not entirely red free, but sufficiently so, to render much more retinal detail apparent for ordinary observation, than is the case when the examination is conducted with ordinary light. With these filters, the macular area is seen in a yellowish or brownish tone, whilst the rest of the fundus stands out as a light apple green background, the vessels traversing the retina being dark brown or blackish, and, therefore, as has already been mentioned, much more distinct by comparison.

Almost any type of self-luminous instrument can now be fitted with specially thin filters of the Wratten type—but unless the source of illumination is unusally good, there may be some little difficulty in studying detail. It is as well, therefore, to choose an instrument which not only has the necessary screen fitted, but which has a sufficiently strong light source incorporated in its design. As a rule, better results seem to be obtained if the screen is interposed in the illuminating beam prior to entry into the eye—rather than to illuminate the eye by means of white light in the ordinary way, and view the fundus picture through a red free screen.

When examining the macular area, it is essential that the patient should be directed to look at a fixed spot, so that the desired area is in the field of view.

In this method, the retina is rendered, as it were, opaque, and the choroid being, therefore veiled, becomes less visible. Essentially the improvement restricts one very largely, to examination of the retinal membrane, particularly the macular region, and for the possibility of the detection of early degenerations in this area, it should be regularly employed.

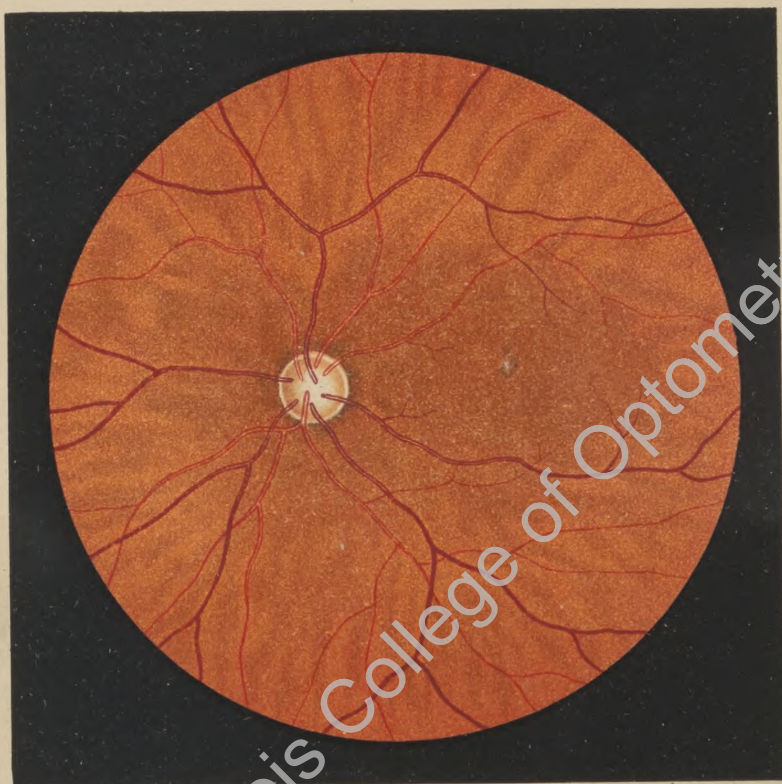


Fig. 1.

Figure 1. Normal Fundus.

The pigmentation of this eye is that of a medium one, the colour being darkest around the optic nerve and behind the macula, and its surrounding region. At the peripheral margin can be seen a flecked appearance caused by an increased amount of pigmentation in the intervascular spaces of the choroid. In front of these lie the retinal blood vessels with their lines of reflection, the arteries being lighter in colour than the veins. The disc has a moderately deep central cupping (physiological) which shows a correspondingly lighter colour, and there is also visible a scleral ring with a rather blurred choroidal ring.

It often happens that the inexpert or inexperienced observer will mistakenly diagnose the dark intervascular choroidal spaces in the normal background, or the brighter striation in between, as disseminated choroiditis. It is always advisable to thoroughly study the various appearances of normal fundi, especially at the periphery, so as to guard against falling into such errors.

Figure 2 a. Longitudinal Section through a Normal Optic Nerve.

This section has been stained with Weigert's stain, and shows the individual nerve fibres losing their medullary sheath as they pass through the lamina cribrosa (the sheath staining black with this preparation). With the loss of this sheathing, the diameter of the nerve itself is diminished. In addition to the medullary sheath, the blood vessels of the nerve, the choroid, the retina, and the tissue surrounding the optic nerve are all stained black. In the disc area, the central retinal vessels (V.C.) are shown partly embedded, appearing somewhat like round cells.

In cases where the medullary sheath is retained by the nerve fibres until they reach the retina, a white radiation is seen all round the disc, such as is represented in Figures 6a, b, and c. This appearance is constantly seen in the eyes of rabbits, and occasionally in those of man—but in a much less marked degree. The ophthalmoscopic appearance of these medullated nerve fibres is a glistening whiteness. They are not transparent, and therefore obscure the retinal vessels.

In this example, there is a noticeable physiological cupping through the nerve fibres diverging after emergence from the lamina cribrosa. This is markedly different in the cases illustrated in Figure 2 b, where the divergence of the fibres is slight. When viewed with the ophthalmoscope, this physiological cupping shows as a pale central portion of the disc, this paleness being caused by the white glistening tissue of the lamina cribrosa being more plainly visible through the diverged nerve fibres. The size of such physiological cuppings varies a great deal, and when it is large it is sometimes difficult to determine whether the excavation is physiological or pathological, as in cases of glaucoma.

V.C. Central Retinal Vessels.

Pig. Pigmented Epithelium layer of the Retina.

Magnification fourteen times.

Figure 2 b. Longitudinal Section through a Normal Optic Nerve showing almost no excavation.

The nerve head rises slightly beyond the level of the retina so that there is a slight papilla. Below the depression, which is very shallow, the central vein and artery of the retina can be traced for a short distance, The specimen has been stained with hematoxylin and eosin. The nuclear and granular layers of the retina show violet and all connective tissue reddish. V.C. Central retinal vessels ; J., Sub-dural spaces between the dural (D), (more strictly speaking, the arachnoidal), and the Pial (P) coatings of the optic nerve. These spaces are crossed by fragments of connective tissue arising from the arachnoidal sheath. c.f., Fig. 21. Magnification fourteen times.

These Figures which accurately show the microscopical sections, show spaces or clefts between the retina and the choroid, or between the choroid and the sclera. It is impossible to avoid this in preparing the sections, and the various layers should be imagined as being in actual contact with each other. The same remark applies to several of the succeeding plates.

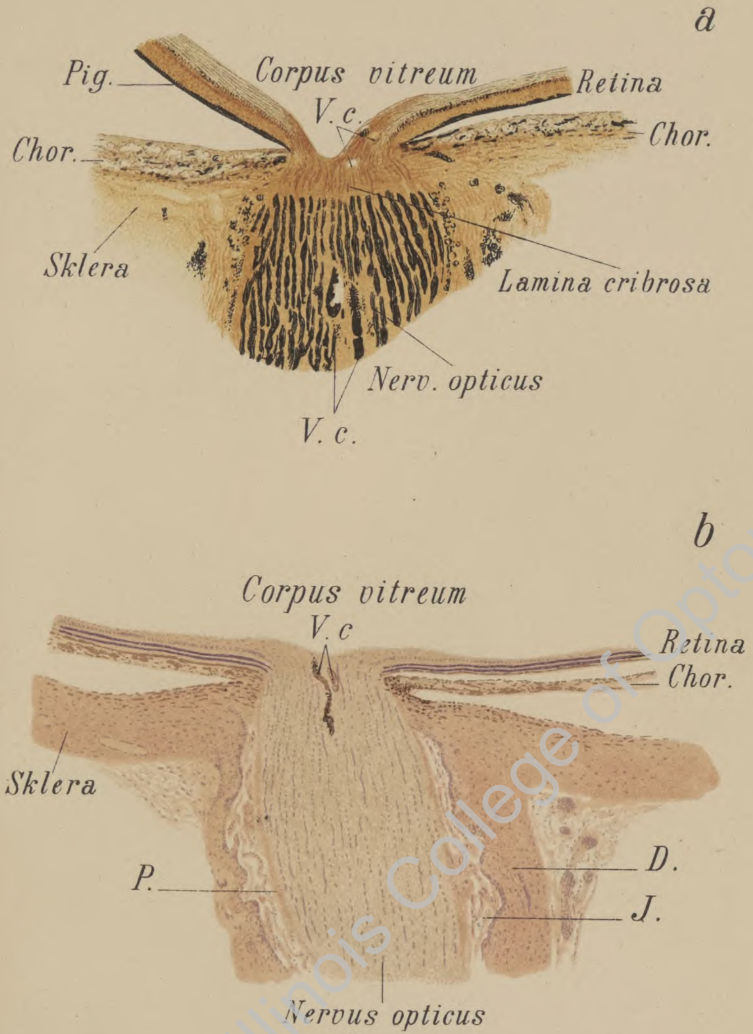
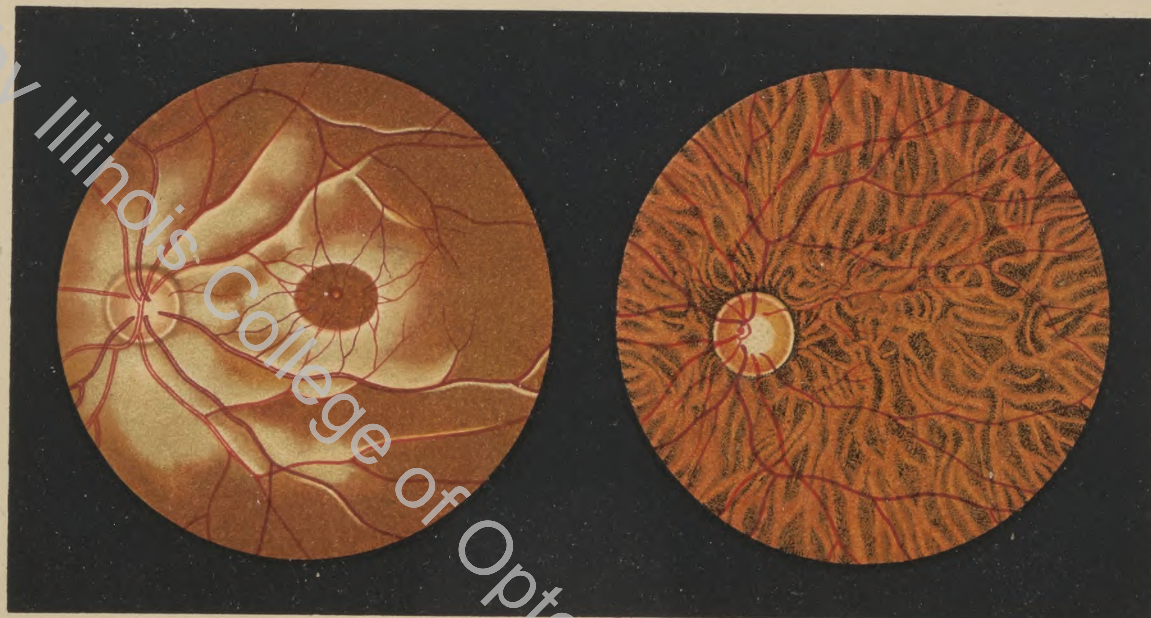

a
Pig.
Corpus vitreum
Retina
V. c.
Chor.
Chor.
Sklera
Lamina cribrosa
Nerv. opticus
V. c.
b
Corpus vitreum
V. c
Retina
Chor.
Sklera
D.
P.
J.
Nervus opticus

Fig. 2.



a Fig. 5. b

Figures 5a and b. Normal Fundi.

Figure 5a shows the background of a very dark eye, and a glistening appearance of the margin of the disc is very apparent. This is frequently very noticeable in the eyes of young people, especially when the pigmentation is dark. The oval in the centre of the figure is the macula reflex and the still smaller and lighter one in its centre is that of the fovea. The pigmentation of the epithelium layer of the retina is so dark that there is no choroidal reflex except a suggestion of red.

Figure 5b shows a background which is also highly pigmented except in the epithelial layer of the retina, the choroid being easily seen. The pigment patches lie chiefly in the spaces between the choroidal vessels, so that these are quite conspicuous. This type is that usually seen in more elderly people. The disc shows a physiological cupping, at the base of which the meshwork of the lamina cribrosa is quite evident. The arrangement of the choroidal pigment, as it appears here, is better shown in the cross section illustrated in Figure 3.

Figure 6a. Medullated Nerve Fibres in the Retina.

Figure 6a shows the fundus of a rabbit, whilst "b" and "c" are those of man. This condition always presents this appearance in the rabbit, the ophthalmoscopic picture rarely varying. Most of the nerve fibres spread out horizontally, appearing like glistening snow-white striae, terminating with fine white filaments. The retinal vessels, spread over these fibres are seen very distinctly, and there is much less difference between the colours of veins and arteries, than is the case with man. The pigmentation of the choroid cannot be seen through the medullated fibres. In the rabbit, the disc is oval shaped with the long diameter horizontal, and there is a well marked physiological cupping.

Figures 6b and 6c.

In man, medullated nerve fibres are not frequently seen, but when they do occur, they present many variations in appearance, with regard to the number and arrangement of the fibres. Here and there, on the background, finely striated, snow white patches, make their appearance, usually at the edge of the optic disc, and the disc margin seems less distinct, being obscured somewhat by the opaque fibres. Sometimes, small patches of medullated fibres may be seen at some distance from the edge of the disc, as shown near the upper edge of Figure "6 b." These medullated fibres often obscure the view of the retinal vessels.

These white patches are harmless, and should not be confused with similar ones seen in albuminura. They are distinguished from these latter by the presence of a hair-like striation which is always seen, especially at the outer edge of the patches.

a

b

c

Fig. 6.

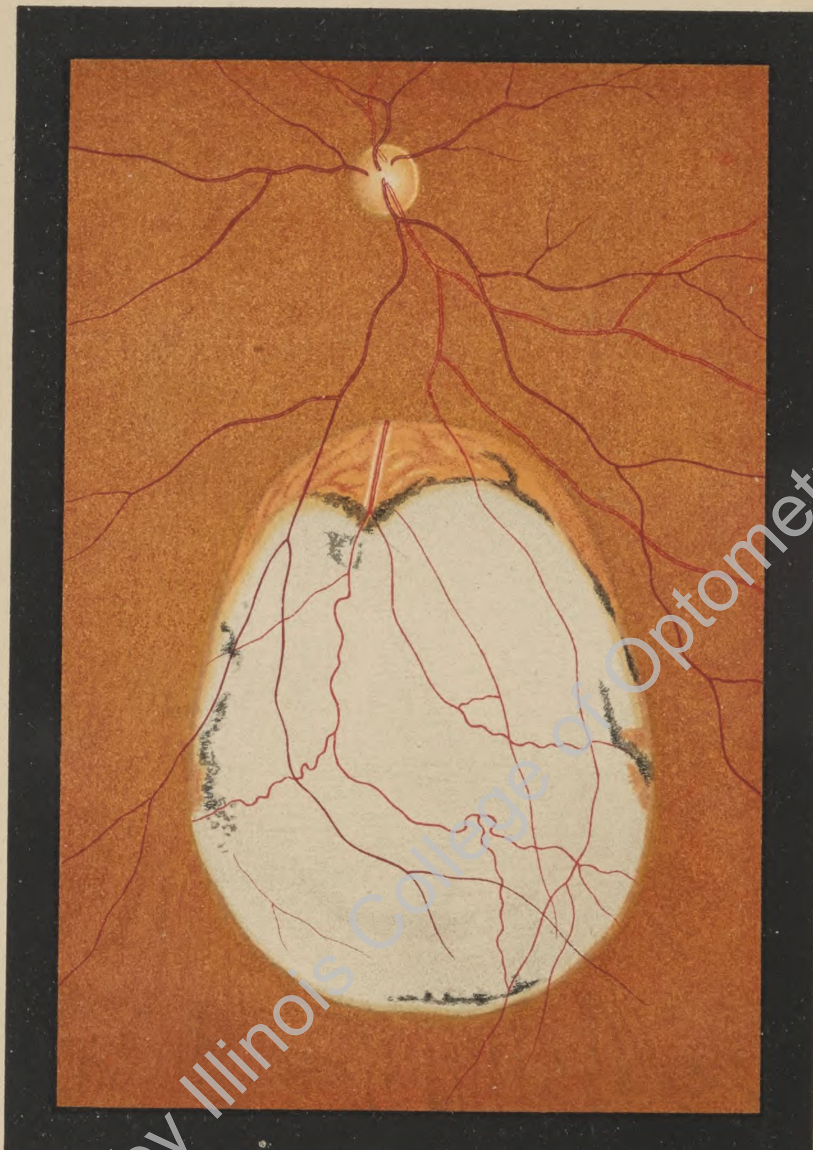


Fig. 7.

Figure 7. Congenital Coloboma of the Choroid.

This defect is seen in the lower portion of the picture, which is really an erect image reduced to the same size as the inverted image.

The sclera is here visible, having a roundish outline, its upper edge being three disc diameters from the optic nerve. At this edge, a small portion of the choroidal tissue is evident, but over the rest of this defective area, the choroidal membrane is only shown by a few scattered pigment patches and still fewer vessels. Some of the retinal vessels are visible against the scleral background. The rest of the fundus is normal.

Such choroidal defects in the lower half of the fundus are presumed to be due to either a persistence of the foetal cleft, or a failure to unite after the cleft. Such a simple explanation, however, is not sufficient. The foetal cleft is in the neighbourhood of the optic vesicle, which later becomes the retina, and as a matter of fact, there is still retina present in the region of the coloboma, and in both this and the succeeding figure, retinal vessels are visible passing across the coloboma. The defect, therefore, cannot be in the optic vesicle, or its cleft—but must be in the layer of mesoderm which ultimately becomes the choroid. These colobomas in the lower half of the eye and the other congenital defects illustrated in the four following figures, are most probably caused in most cases by intra-uterine disease, and it is more likely that the foetal cleft plays only a secondary part in the group of such cases of inferior colobomas of the iris or the choroid.

Figure 8a. Congenital Coloboma of the Choroid and Malformation of the Optic Nerve.

Erect image reduced to the same size as the inverted image.

In this case the choroidal defect surrounds the disc which is greatly increased in size. The track of the vessels leaving the optic disc is quite abnormal. The disc itself and the portion of the sclera seen immediately below it are cupped (ectatic), the entire cavity containing three smaller patches, two oval and one round (staphylomata).

Some retinal and choroidal vessels may be seen crossing the coloboma.

Figure 8b. Congenital defect of the Pigmented Epithelium layer of the Retina at the region of the Macula.

The two whitish patches are defects in the choroidal tissue through which the sclera is visible. They are crossed by some choroidal vessels. At the edge of the optic disc there is another triangle-shaped choroidal defect. The dark orange coloured patches show where the pigmented epithelium of the retina is absent, though some irregular lines of pigmentation are visible, the rest of the fundus being normal. The fellow eye showed similar changes.

a

b

Fig. 8.

a Fig. 9. b

Figure 9 a. Congenital Coloboma of the Retinal Pigment and, in places, also of the Choroid.

This defect is on the outer and upper side of the disc—the image being inverted. The retinal vessels are seen passing continuously over the brighter patch which is edged with some darker pigmentation. The edge of the area is a succession of small curves, and choroidal vessels without pigmentation in the intervascular spaces are seen crossing the entire patch. The two small dark areas are probably collections of retinal pigment. The rest of the fundus appears normal, and the fellow eye was quite normal.

Figure 9 b.

Congenital Coloboma of the Choroid on the nasal side of the disc. This defect is circular and edged with pigment. The choroidal structure is entirely absent and the white sclera is seen. Retinal vessels cross the patch. The rest of the fundus is normal and that of the fellow eye was also normal.

Such congenital defects of the choroid are as a general rule probably caused by intra-uterine diseases.

Figure 10 a.

Congenital Coloboma of the Choroid situated above the posterior pole of the eye (inverted image) and edged with a sinuous line of pigmentation. In the upper portion of the defective area some choroid is still intact, but in the lower portion the white sclera is seen. Retinal vessels are seen crossing the patch without any interruption. The disc is edged with a circle of atrophied choroid caused by myopia. The fellow eye showed a similar choroidal defect similarly situated just above the posterior pole.

Figure 10 b. Congenital absence of Pigmentation (Albinism).

Only a small portion of the fundus is shown here, being an area situated at the periphery of the lower half of the eye near to its equator. A vortex vein is seen (one of the chief vein trunks of the choroid) with many of its tributaries. There is an entire absence of both retinal and choroidal pigmentation, so that the choroidal vessels are clearly visible against the white scleral background. It so happens that no retinal vessels can be seen, this being due to their minuteness and their sparse distribution at the peripheral portions of the fundus.

a Fig. 10. b

Fig. 11.

Figure 11.

Congenital Dislocation of the Lens, into the lower and outer segment of the right eye (inverted image). When a condensing lens was held in a suitable position, the edge of the crystalline lens could be seen passing obliquely across the ophthalmoscopic field, and the disc area appeared to be doubled, the smaller image somewhat oval in shape, being seen through the peripheral portion of the crystalline and the other being viewed outside its edge. The disc shows a crescent of atrophied choroid with its concavity downward, such as is frequently seen in cases of myopia, especially when occurring with congenital amblyopia and astigmatism.

Figure 12 a.

Inflammation of the Optic Nerve (Optic Neuritis) in the early stage. The edge of the disc is blurred and indistinct, and its whole area reddened, so that it does not look clear and is somewhat difficult to examine. By using the direct method and by means of parallactic displacement, as explained in the introduction, some slight swelling of the papilla may be seen. The retinal vessels show nothing unusual and the rest of the fundus appears normal.

Figure 12 b. Inflammation of the Optic Nerve in a more advanced Stage.

The disc area appears to be much enlarged, although on account of some retinal opacity around the disc area, its edges are very indistinct. The swelling of the papilla is much more marked (Hugel). The retinal veins are much enlarged on account of stasis, whilst the arteries are contracted.

a Fig. 12. b

a Fig. 13. b

Figure 13 a and b. Bilateral Inflammation of the Optic Disc in a Case of Tumour of the Brain (Choked Disc or Papillitis).

The disc diameter is much increased, and owing to oedema and the swelling due to the inflammation, the papilla shows as a distinct prominence, towards the centre of which the vessels seem to be descending. The veins are tortuous and much dilated through obstruction. Around the disc area the retina is striated and slightly opaque. In the left eye a whitish crescent is seen around the margin of the disc, probably due to a folding of the retina. (The case was a patient in Prof. Eichhorst's clinic).

The anatomical changes in Papillitis are further explained in Figures 15 a and b.

Figure 14 a. Horizontal Section through a Normal Macula Lutea almost exactly through the centre of the Fovea centralis (F.C.)

After immersing the freshly excised globe in a warm saturated solution of bichloride of mercury, and hardening in alcohol, a section was stained with Hematoxylin and Eosin. The steepness of the walls of the physiological cupping was probably less in the living eye than appears in the section. At the base of the cup, the retinal layer is reduced almost entirely to the slender cones with their fibres and nuclei. In the internuclear layer the fibres diverge somewhat, owing to some mishandling in the preparation of the section (this is more apparent in Figure 14 c). For this reason, the walls of the cup are rather steeper than normally.

Magnification fourteen times.

Figure 14 b.

Shows the outline of the same section but under the higher magnification used in the succeeding figure.

Magnification thirty times.

Figure 14 c.

Another section from the same specimen also through the fovea and including the surrounding choroid and sclera, under higher magnification. There is a small prominence at the base of the cupping which is a fault of preparation of the section. Adjoining the layer of pigmented epithelium can be seen the layer of capillaries of the choroid. At the posterior edge of the sclera there are several transverse and oblique sections of posterior ciliary arteries (V). The section was stained similarly to that illustrated in Figure 14 a.

The picture also shows the relative thicknesses of the three coats of the globe—retina, choroid, and sclera.

Magnification thirty times.

In both sections can be seen, at the upper margin, the internal limiting membrane, which was slightly parted from its foundation when preparing the specimen.

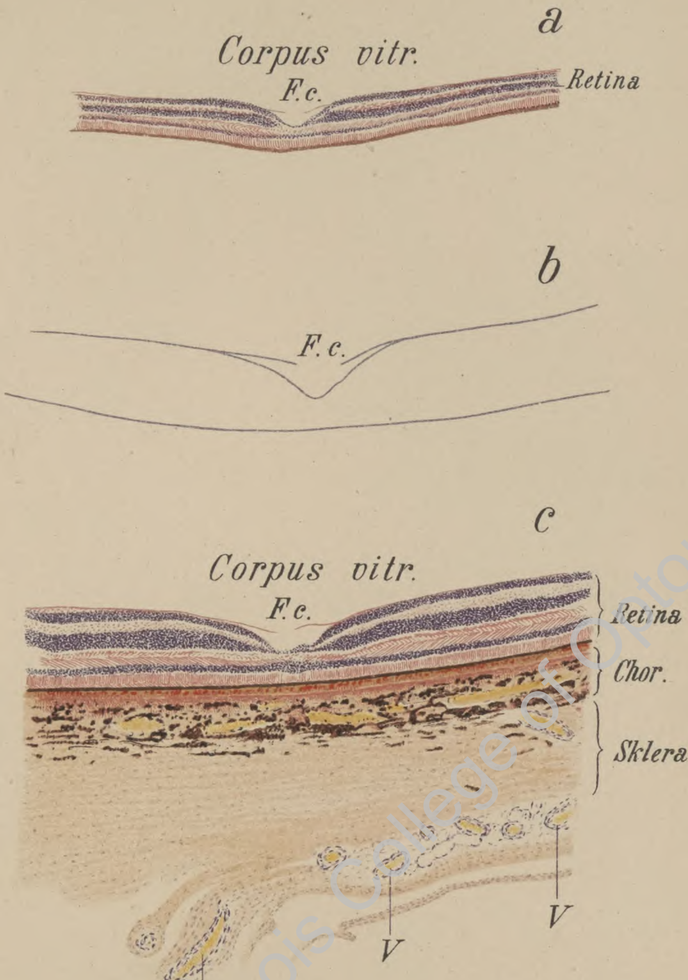

a
Corpus vitr.
F.c.
Retina
b
F.c.
c
Corpus vitr.
F.c.
Retina
Chor.
Sklera
V
V
V

Fig. 14.

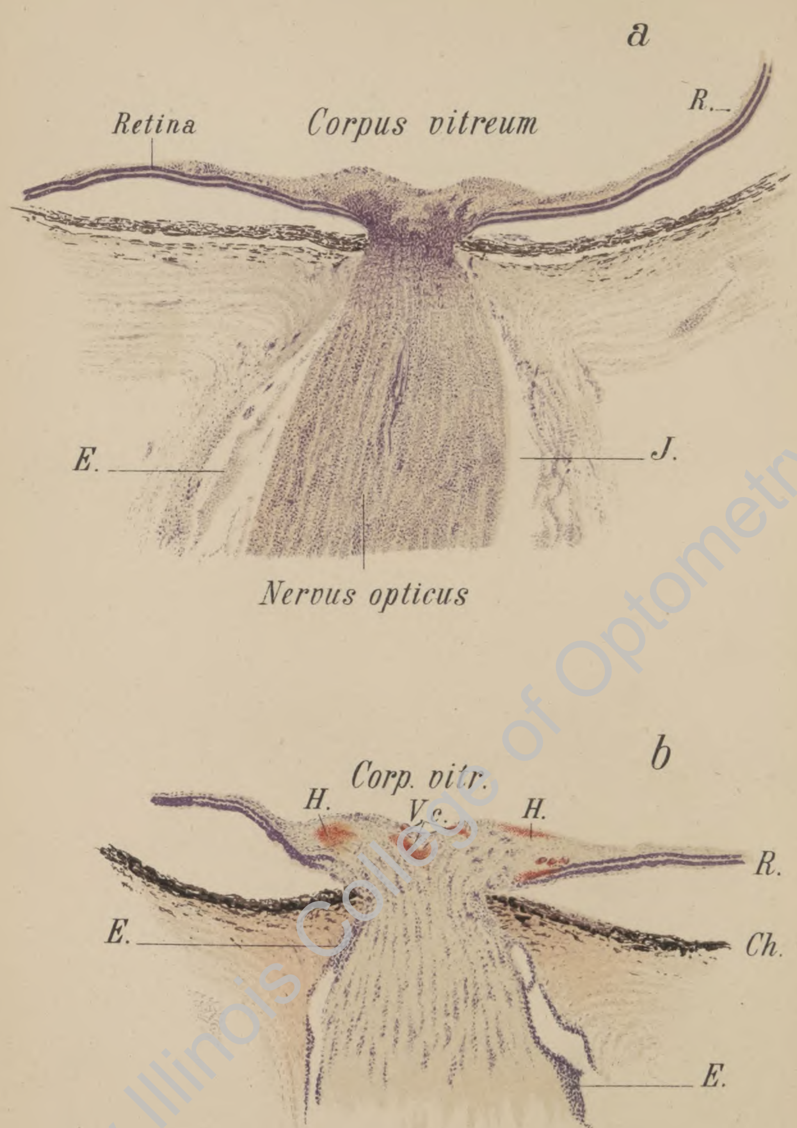

a
R.
Retina
Corpus vitreum
E.
J.
Nervus opticus
b
Corp. vitr.
H.
Vc.
H.
R.
E.
Ch.
E.

Fig. 15.

Figure 15 a.

Longitudinal Section through the Disc in Optic Neuritis (Choked Disc, Papillitis) due to tumour of the brain (sarcoma of the central lobe). The specimen is stained with Hematoxylin. In this case the papilla is only moderately swollen. This swelling may be much more marked in such cases, even more so than is shown in the following picture. The cleft between the retina and the choroid is a fault of preparation.

Between the lamina cribrosa and the anterior retinal surface there is much inflammatory infiltration (proliferation of nuclei). In the sub-dural space (J) can be seen a few areas of inflammatory exudate (E).

In the optic nerve trunk, in the centre of which is a section of a central retinal vessel—there is also visible some moderately well defined inflammatory proliferation.

E.—Inflammatory exudate in the sub-dural space of the Optic Nerve ;
J.—Sub-dural space ;
R.—Retina. Magnification fourteen times.

In such a case the disc and its surroundings would first present the appearance shown in Figure 12a, and later that depicted in Figure 13b.

Figure 15 b.

Longitudinal Section through the Disc in Optic Neuritis and Papillitis resulting from brain tumour with purulent meningitis, which terminated fatally after trephine operation. Specimen stained with Hematoxylin and Eosin. The swelling of the papilla is even more prominent than in the preceding case, and would seem even more pronounced, if the retina had not become detached from the choroid when preparing the section. The lateral extension of the swelling beyond the edge of the disc is plainly seen and this produces the apparent enlargement of the papilla when viewed with the ophthalmoscope. The pronounced dilation of the vessels, especially the central retinal vein (V.C.) is very apparent, and hemorrhages into the retinal fibres (H) can also be seen. There is also marked inflammatory exudate in the sub-dural space.

V.C.—Central Retinal Vessels. E.—Exudate in the sub-dural space.
Ch.—Choroid. R.—Retina. H.—Hemorrhages.
Magnification fourteen times.

The ophthalmoscopic view of such a case would be similar to that shown in Figures 17 and 18.

Figure 16.

Inflammation of the Optic Nerve and adjacent portions of the Retina in Syphilis (so-called Specific Neuro-Retinitis). There is marked blurring of the disc area and its surroundings, partly due to a diffused central opacity in the vitreous. The peripheral portions of the fundus in this case show no signs of disease, but in many such cases, spots of disseminated choroiditis in various stages of development are to be seen. This appearance is characteristic of syphilis, and warrants one concluding with some certainty that such a disease is present.

The vitreous opacity may disappear with suitable treatment, but usually an apparent atrophic discolouration of the disc still persists. Small spots of choroiditis may develop near the peripheral margin during the course of the disease.

Fig. 16.

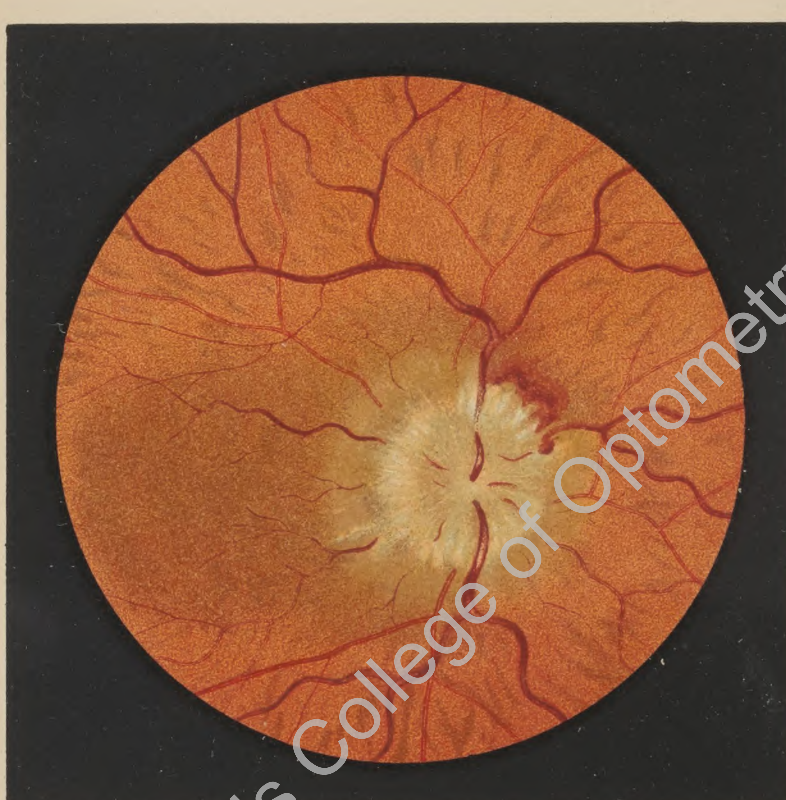


Fig. 17.

Figure 17.

Intense Inflammation of the Optic Nerve (Papillitis). After meningitis caused by a blow on the head. In both eyes there is marked infiltration of the nerve tissue, owing to the inflammation, and showing as grey-white patches and striae on the disc area and the immediately adjacent portions of the retina, and in some hemorrhages seen at the lower outer edge of the discoloured area. The diameter of the disc appears to be enlarged and the papilla seems swollen and prominent. Owing to the exudate present in the nerve tissue the venous flow from the retina is obstructed and the veins therefore appear to be dilated and tortuous. (The case was a patient at Prof. Eichhorst's Clinic).

The microscopic appearance of such a case would be similar to that depicted in Figure 13 b.

Figure 18. Marked Inflammation and Congestion of the Optic Nerve, in a Case of Orbital Tumour.

Exophthalmos (protusion of the globe) was present. In this picture the intraocular termination of the optic nerve shows much swelling caused by the inflammation and oedema. The inflammatory infiltration shows as whitish striations. The retinal veins are much congested, and numerous hemorrhages have occurred in consequence. The retinal arteries are only moderately distended.

Fig. 18.

a Fig. 19. b

Figure 19 a. Atrophy of the Optic Nerve after Inflammation.
(Neuritic Atrophy).

The entire disc is white, its margin blurred, and no lamina cribrosa is visible. The whitish colour is due to connective tissue, which as a consequence of previous inflammatory products, covers the entire disc area. The white lines on some of the blood vessels (adventitious stripes) are due to a thickening of the walls of the vessels. At the borders of the disc lie lines of pigment, and there is a lighter ring around the edge of the disc, both of which indicate a certain amount of proliferation of the choroidal pigment with consequent choroidal atrophy, and both are caused by the inflammation of the optic nerve. The appearance of the vessels is normal, later these appeared to shrink slightly.

Figure 19 b.

Atrophy of the Optic Nerve after Interruption of the Conducting Power of the nerve fibres, owing to a fracture of the optic canal, consequent on a fall on the head. The disc appears normal, with the margin well defined, but the colour is white (with some suspicion of grey). There is no undue dilation of the retinal vessels, and in such a case, they might not contract for a long while. This type of atrophy is differentiated from the genuine grey variety by this contraction of the vessels, which is much more rapid in the grey cases. In the course of some years after the interruption of the conducting power of the optic nerve fibres, the disc colour will eventually become greyish—but the vessels will maintain a normal appearance for even a longer time.

Figure 20 a. Commencing Grey Atrophy of the Optic Nerve.

The change in colour of the disc is already very evident on the temporal half, though less pronounced on the nasal side. The lamina cribrosa can be easily seen at the centre of the disc. The retinal vessels, especially the arteries, are already showing slight contraction.

Figure 20 b. Advanced Grey Atrophy of the Optic Nerve.

The colour change is much more apparent than in the previous case, the lamina cribrosa being more exposed and is, therefore, more clearly seen. The disc margins are still quite crisp—but the retinal vessels, especially the arteries, are becoming smaller and smaller.

For the anatomical appearance of both partial and total atrophy of the optic nerve see Figures 21 a and b.

a b

Fig. 20.

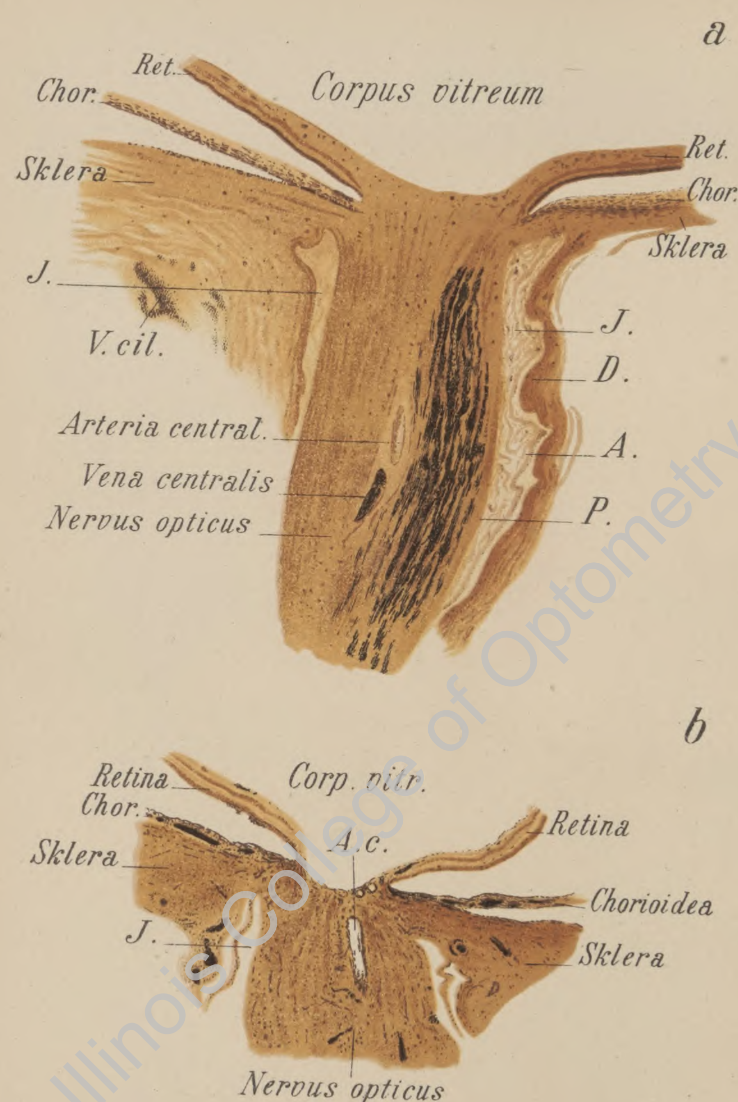

a
Ret.
Chor.
Corpus vitreum
Sklera
Ret.
Chor.
Sklera
J.
V. cil.
J.
D.
Arteria central.
A.
Vena centralis
Nervus opticus
P.
b
Retina
Chor.
Corp. vitr.
Retina
Sklera
A. c.
Chorioidea
J.
Sklera
Nervus opticus

Fig. 21.

Figure 21 a. Longitudinal Section through the Disc in Partial Atrophy of the Nerve.

The section is stained by Weigert's method, which colours the medullary sheath of the nerve fibres a bluish black. This medullary sheath is totally absent in the atrophied left hand half of the nerve trunk. On account of the partial atrophy (and as a consequence some diminution in the size of the nerve,) the subdural space is rather wider than usual, and the arachnoidal sheath is more easily seen.

The papilla is distinctly flattened as a result of atrophy.

D. Dural Sheath.	A. Arachnoidal Sheath.
P. Pial Sheath.	V.Cil. Ciliary Vessels.

Magnified 14 times.

Fig. 21 b. Longitudinal Section through the Disc in Total Atrophy of the Optic Nerve. *Stained by Weigert's Method.*

Here the medullary sheath is totally absent, and the nerve trunk is even thinner than in the case shown in Fig. 21a. The papilla, owing to the atrophy, exhibits distinct excavation, at the floor of which the lamina cribrosa is visible. A section of the central retinal artery is seen in the Figure.

This microscopic appearance corresponds to the fundus picture which is shown in Figure 20b. The patient from whom this section was taken, when first examined with the ophthalmoscope, showed a commencing grey atrophy just like that illustrated in Figure 20a, and later there was more advanced discolouration of the disc, such as is shown in Figure 23. He later developed progressive paralysis and died in a lunatic asylum. The posterior half of the globe was then presented to me by Professor Florel.

Magnified 14 times.

Figure 22. Atrophy of the Optic Nerve due to Increased Intra-ocular Tension. (Glaucoma).

The entire disc area shows evident cupping and dark grey discolouration. The lamina cribrosa is pushed back and more easily seen on account of the disappearance of the nerve fibres. There is atrophy of the choroid around the disc margin, forming a pale circular band which is known as the glaucomatous halo. The retinal vessels bend over sharply at the edge of the disc, and dip down to the floor of the cup, some of them being visible again on the lamina cribrosa. When first seen, the veins appeared dilated and congested, and as now depicted the retinal vessels also are commencing to atrophy. By parallactic displacement and measurement of the erect image as explained in the introduction, a distinct displacement of the disc edge in front of the floor of the cup is apparent, and the depth of the cup is calculated to be 2 mms. (equal to a refractive difference of 6 D between the two positions).

The microscopic changes in such glaucomatous cuppings is shown in Figures 24 c and d.

Fig. 22.

a Fig. 23. b

Figure 23 a. Commencing Glaucomatous Cupping of the Optic Disc, which is present only in the temporal half, the nasal half not yet showing signs of any excavation or cupping. This nasal half of the disc is somewhat reddened, and at its temporal edge several vessels can be seen dipping down into the cup. The lamina cribrosa is seen comparatively uncovered with nerve fibres. That portion of the disc which is cupped, has a typical grey atrophic appearance. Since the cupping extends to the margin of the disc, it is evident we are dealing with a glaucomatous condition and not one of physiological excavation.

Figure 23 b. More Advanced Glaucomatous Cupping of the Optic Disc.

On account of the presence of numerous retinal haemorrhages, this case is a typical one of haemorrhagic glaucoma. Only one quarter of the disc on the nasal side is not yet excavated, and this is considerably reddened. The remainder of the disc is considerably cupped and exhibits typical grey atrophy, a considerable portion of the lamina cribrosa being visible. The retinal veins are engorged, this being partly due to stasis produced by the kinking and compression of the portion of the vein on the disc area, as a result of the high intraocular tension.

Figure 24 a. Meridional Section through the region of the Angle of the Anterior Chamber in a Normal Eye.

The cleavage between the ciliary body and the scleral tissue occurred during the preparation of the section, but the relative position of the iris is approximately normal and indicates the appearance of the angle between the ciliary attachment and the cornea.

C.V.C.—Circulus venosus ciliaris, or Schlemm's Canal, or in the nomenclature of the Anatomical Society " Sinus Venosus Sclerae."

L.P.—Pectinate Ligament.

Magnification 14 times.

Figure 24 b. Section through the same region showing obliteration of the Angle of the Anterior Chamber as often occurs in cases of Glaucoma.

Normally the aqueous humour leaves the globe through the angle of the Anterior Chamber ; blocking of the angle therefore restricts this drainage, and thus the rise in internal pressure is explained in cases of glaucoma. The aqueous humour is imprisoned within the globe, giving rise to additional symptoms of glaucoma, especially the cupping of the disc by the increased pressure. This latter change is shown in the two following pictures.

Magnification 14 times.

Figure 24 c. Longitudinal Section through the Optic Disc in advanced Glaucoma.

The cupping of the disc due to increased internal pressure of the globe is quite evident. A cavity with deep sides replaces the papilla, and the lamina cribrosa constitutes the floor of this cavity with additional nerve fibres which have not yet become atrophied by the pressure and the kinking at the edge of the cup.

Magnification 14 times.

Figure 24 d. Longitudinal Section through the Optic Nerve in a more advanced Case of Glaucoma.

Here the diminution in the diameter of the nerve trunk is well marked—this being of course caused by the atrophy of the individual nerve fibres, and an increase is noted in the width of the sub-dural space surrounding the nerve. In this section there is a very pronounced cauldron-shaped cupping of the disc of the type which frequently occurs in glaucoma. As the nerve grows more tenuous between its anterior surface and the lamina cribrosa, as depicted in Figure 2a, the cupping is apt to assume this cauldron shape, becoming, so to speak, narrower in front than behind, the lamina cribrosa being at the same time pushed backwards as a result of the increased pressure.

To a certain limited extent the same process can be observed in Figure 24c.

Magnification 14 times.

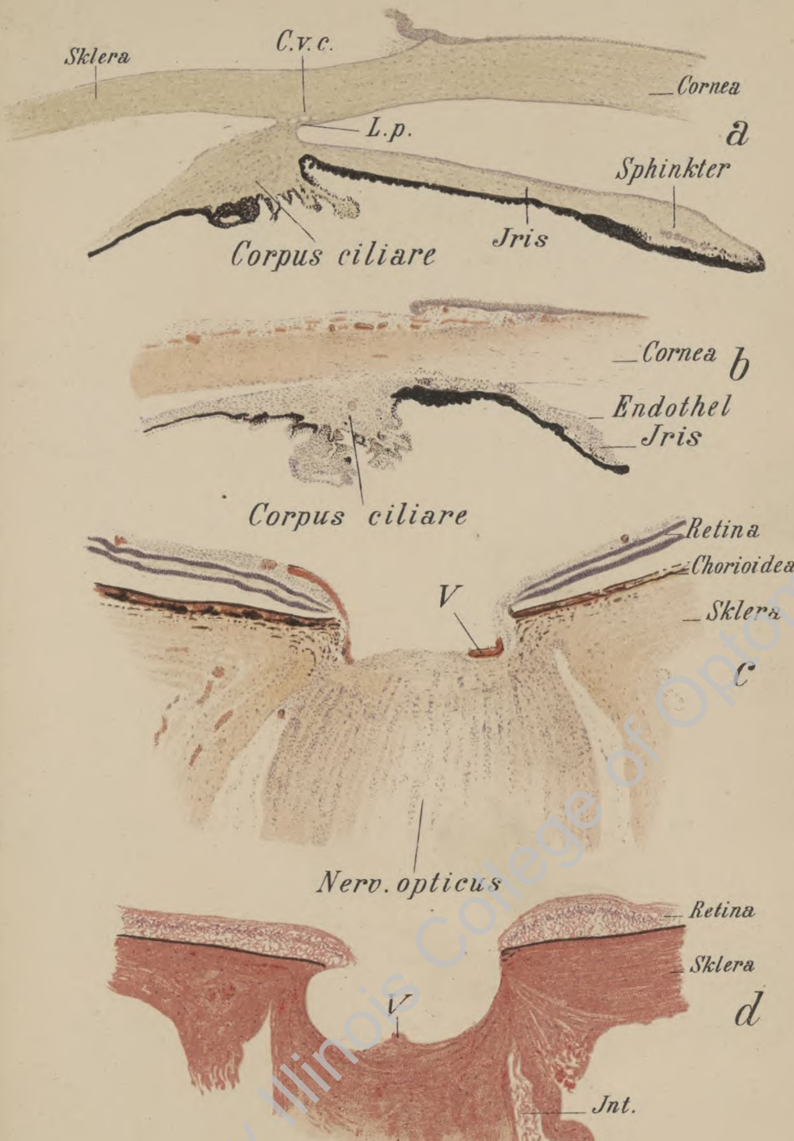

Sklera
C.v.c.
Cornea
L.p.
a
Sphinkter
Corpus ciliare
Jris
Cornea
b
Endothel
Jris
Corpus ciliare
Retina
Chorioidea
V
Sklera
c
Nerv. opticus
Retina
Sklera
V
d
Jnt.
Nerv. opticus

Fig. 24.

a Fig. 25. b

Figures 25 a and b. Alterations in the Retina and of the Optic Disc in Albuminuria, (Neuro-retinitis Albuminurica) of both eyes.

In the disc area, the inflammation shows itself by some reddening and a partial blurring of the margin. The adjacent retina is somewhat opaque and striated. Away from the disc there are haemorrhages and certain white patches which are generally round in shape and which are due to degeneration and inflammation. At the macular region, these white patches assume the form of a star-shaped figure, at the centre of which the background appears to be more deeply pigmented.

These albuminuric accumulations in the retina (and also those occurring in diabetes and some other retinal diseases) are composed of several ingredients. An anatomical investigation shows the presence of cells containing fat granules, thick masses of swollen nerve fibres, accumulations of fibrin exudates, amorphous collections of round cells, for the most part probably consisting of white bloodcells. The microscopic appearance of some of these changes is shown in Figures 26 and 27.

The sclerosis of the arteries (c.f. Figure 27c) which is well marked in the retina in albuminuria, cannot generally be observed in the ophthalmoscopic picture (as is also the case in atheroma) but has to be studied in a microscopical section. Similar changes are also found in the choroidal vessels.

Figure 26 a. Section through a Retina in a case of Albuminuric Retinitis. Section stained with hematoxylin and Eosin.

The changes produced by this disease will be immediately apparent if this picture is compared with Figure 3. Several haemorrhages—which are stained red by the Eosin—are observed in the anterior layers of the retina. There are a number of gaps between the fibres of the outer reticular layer, these being a result of oedema and exudation. At one spot, which is stained very dark, there is visible a mass which probably consists of fibrin exudate (c.f. Figure 27).

In the nerve fibre layer, similar gaps are to be seen, these containing a number of swollen nerve fibres, which are shown under a higher degree of magnification in Figures 26b and c.

Magnification 20 times.

The section corresponds approximately to the ophthalmoscopic appearance shown in Figures 28 a and b, the spots visible on the fundus corresponding anatomically to the patches of fibrin exudate shown in Figures 26 and 28, or to the swollen nerve fibres which are frequently massed together in bundles, or possibly to heaps of wandering leukocytes and tissue cells, more or less in a stage of advanced fatty degeneration. Such fatty degeneration is not depicted in this section, which does, however, show masses of wandering lymph corpuscles, which are scattered promiscuously in the retinal tissue.

Figure 26 b and c.

Swollen nerve fibres from the section shown in Figure 26a under a higher degree of magnification. Amidst the thickened spindle-shaped nerve fibres (stained violet with hematoxylin) will be seen the nuclei of lymph corpuscles or inflammatory leukocytes.

Magnification 112 times.

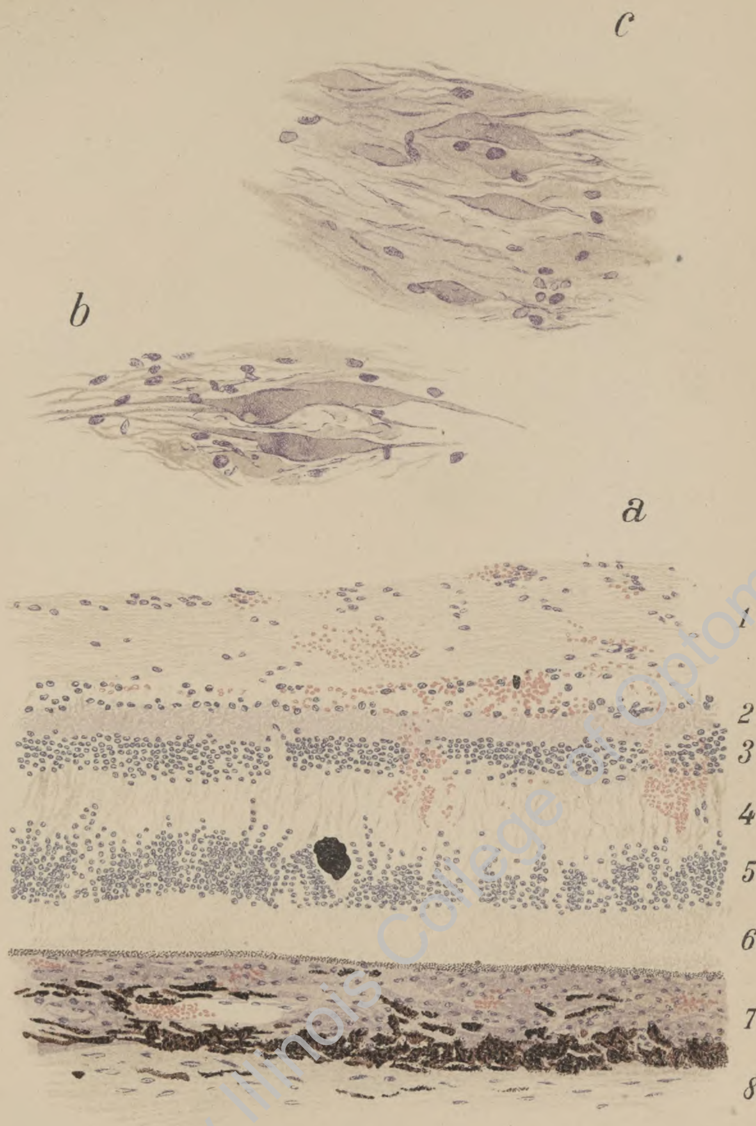


Fig. 26.

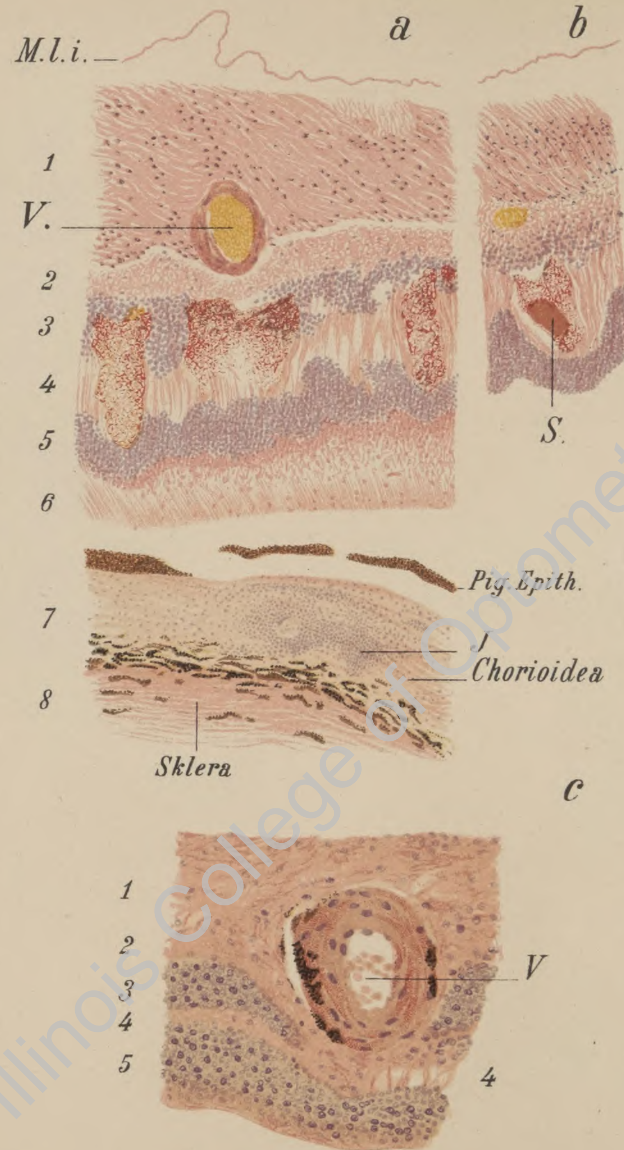

M.l.i.
a
b
1
V.
2
3
4
5
6
1
2
3
4
5
S.
Pig. Epith.
7
J
Chorioidea
8
Sklera
c
1
2
3
4
5
V
4
Fig. 27.

Figure 27. Alterations in the Retinal Structure in Albuminuric Retinitis.

"*a*" shows a section through retina, choroid, and a portion of the sclera in which it will be noticed that between the layer of rods and cones and that of pigmented epithelium cells, a cleft has been formed in preparing the section and the parting of the internal limiting membrane from the nerve fibre layer likewise arises from the same cause.

"*b*" shows another section of the same preparation. In these sections, in the layers of nerve fibres and ganglionic cells, a deposition of leukocytes is visible amidst the tissues, especially in Figure "b." On account of oedema and the infiltration of irregularly shaped masses of exudate, the lymph spaces seem abnormally wide. A strong fibrous network of exudate deposit is seen in the outer reticular layer (this being stained red by the eosin). In figure "b" in the midst of the fibrin is seen an amorphous mass, similar to that shown in Figure 26. Also in the outer reticular layer there is displayed an oedematous condition (larger gaps between the fibres). The layer of rods and cones is degenerated, in parts forming round granules and appearing disseminated. In the choroid there is a well defined inflammatory infiltration (J). The blood vessel (V) in Figure "a" exhibits very little thickening of the walls due to the inflammation, whilst in that shown in Figure "c" very marked thickening is noticeable, this latter, furthermore, containing granules of pigment.

1. Layers of nerve fibres and ganglionic cells.
2. Inner reticular layer.
3. Inner nuclear layer.
4. Outer reticular layer.
5. Outer nuclear layer.
6. Layer of rods and cones.
7. Choroid.
8. Sclera.

Magnification of "a" and "b" 122 times and of "c" 150 times.

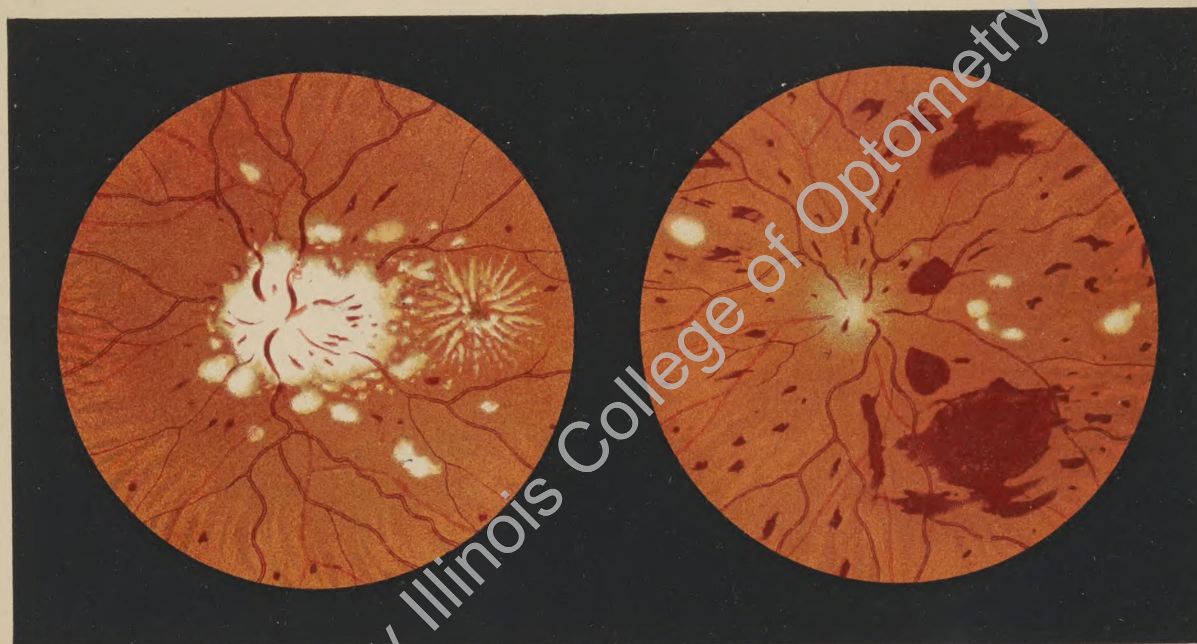
Figure 28 a. More strongly marked Albuminuric Changes of the Retina and the Disc than those shown in the preceding case.

The white patches of degeneration are much more strongly marked, as are those also in the stellated figure. The position of the disc is only determined by the joining together of the engorged veins, and a very few small arteries. All the retinal arteries are sparsely filled with blood, and haemorrhages are frequent, but small.

What constitutes the anatomical formation of the stellate figure is probably a heaping up of fat granules in the layer of cones (Dimmer), rather than some fatty degeneration of the inner extremities of the Muller's supporting fibres of the retina, as was formerly believed. The cones and their fibres (c.f. Figure 14c), leave the fovea centralis radially, and thus any deposition of fat granules between the fibres would result in the formation of this stellate figure. This occurs not only in albuminuria, but also in Neuritis following a brain tumour, in retinal haemorrhages in young people (c.f. Figure 35), and in Syphilitic neuro-retinitis (c.f. Figure 37).

Figure 28 b.

In this case of Albuminuric disease of the retina there are numerous haemorrhages in the retina—but on the other hand, the white patches are more scanty. The disc shows inflammation (Papillitis). The veins are much engorged and tortuous. No stellate figure is visible. The picture has more the appearance of an ordinary haemorrhagic retinitis or thrombosis of the central vein, but the inflammatory condition of the disc must arouse a suspicion of an albuminuric causation. Thus with albuminuria, there may merely be the appearance of a marked neuritis (Papillitis), which might be erroneously diagnosed as some brain disease.



a Fig. 28. b

a Fig. 29. b

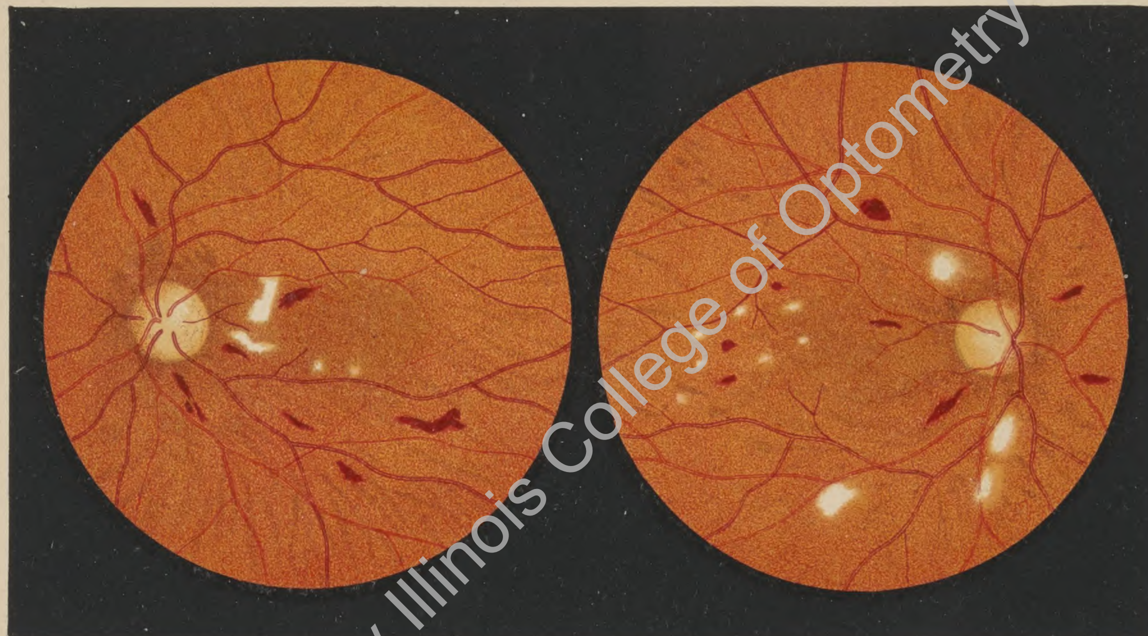
Figure 29 a, and b. Incipient Albuminuric Retinitis of Both Eyes.

At the disc, this inflammation commences to be visible by a partial blurring of the margin at the nasal edge, and to some extent on the contiguous upper and lower edges. In the retina can be seen some haemorrhages and whitish patches, but there is no stellate figure noticeable. This condition comes under the observation of the skilled observer much more frequently than those depicted in Figures 25 and 28. The discovery of even a very few red and white patches in the retina should always suggest the necessity for a complete analysis of the urine. In very similar conditions to the case here depicted, sugar might be found instead of albumen, as the succeeding picture will show.

Figure 30 a and b. Fundus Changes in Diabetes, (Retinitis Diabetica) in Both Eyes.

The condition seems very similar to the preceding case of Albuminuria. The white patches in the retina form no star-shaped figure, and retinal haemorrhages exist in fairly large numbers.

One often finds a greater number of the white patches in a case of diabetes, in fact, the fundus may appear to be bestrewn with them. Usually they are only small in size and are seen particularly in the region of the posterior pole of the eye. It is probable that they represent patches of degeneration of a similar type to those found in Albuminuria.



a Fig. 30. b

Fig. 31.

Figure 31. Fundus Changes in Pernicious Anaemia.

The fundus seems rather paler than usual, and in consequence of the anaemia, the disc seems to have a rather faded appearance. The arteries seem thin, but the veins are quite dilated. In the retina several haemorrhages are seen, a number of these seeming paler in the centre, which is somewhat suggestive of pernicious anaemia, although such are also found in other types of retinal haemorrhage. In the region around the disc area some white patches are seen. The patient (from the Clinic of Professor Eichhorst) died very shortly after this fundus drawing was made.

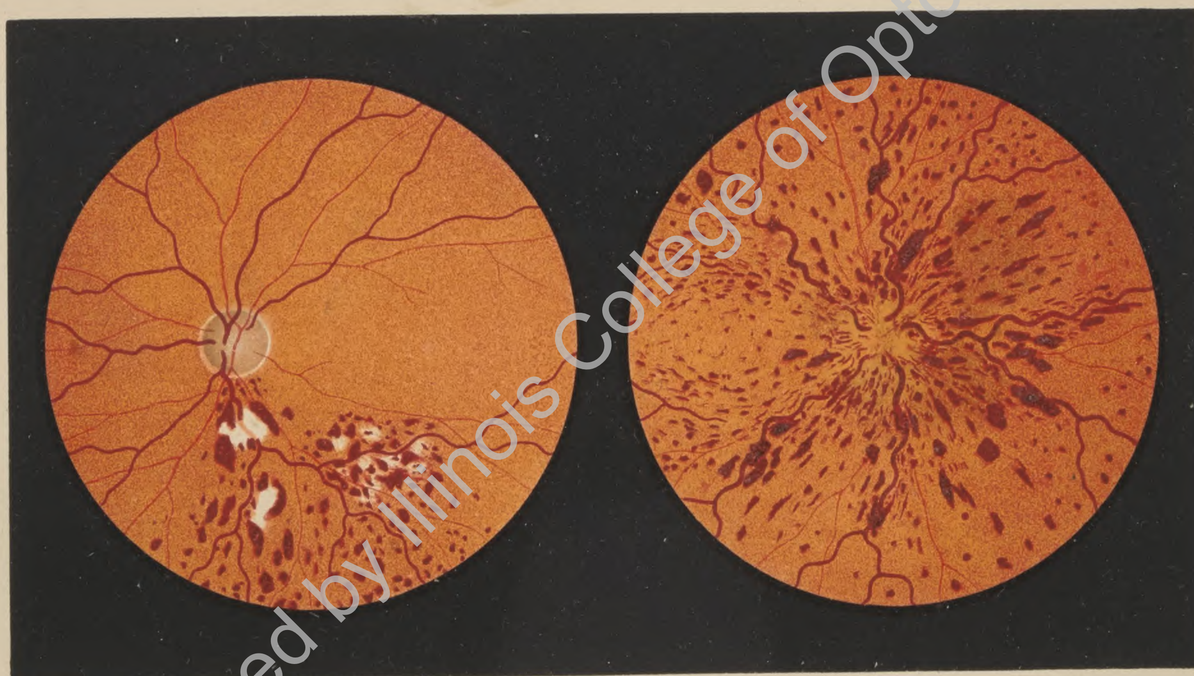
In Figure 67 a, is shown a microscopic section of a portion of a retina with haemorrhages of this type.

Figure 32. Obstruction of the Central Retinal Artery.

A thick clouding of the retina obscures the disc margins and covers the entire area of the posterior pole of the eye. At the milky white patches the vessels are seen very indistinctly, as if they were interrupted, especially around the disc area, but in the macular area, even the minuter retinal vessels seem very distinct. On the central foveal area, a cherry red spot is visible, which is not due to haemorrhage, but on account of this being the thinnest patch of the retina, the choroidal reflex is seen more strongly, and its red colour shows up more intensely, by contrast with the white surroundings. At their commencement, the arteries appear to be only sparsely filled, but later they regain a more normal appearance, still, however, seeming thinner than the veins. In the arteries, the blood column seems interrupted in places as if broken into smaller sections. The retina is normally transparent at the periphery, so that the pigmentation of the intervascular spaces of the choroid is easily visible.

The obstruction of the central retinal artery, which causes this ophthalmoscopic appearance, has hitherto always been attributed to embolism. My own opinion is that it is oftener thrombosis or contraction and closure through obliterating endarteritis, that is responsible for the disturbance in the circulation, and that only in very rare cases is embolism the cause.

Fig. 32.



a Fig. 33. b

Figure 33 a. Thrombosis of the Superior Temporal Vein—so-called Haemorrhagic Retinitis.

In the path of this branch of the retinal veins, there are to be seen several linear and circular haemorrhages, and amongst them are scattered white patches of degeneration. The obstruction in the vein is very near to the disc (and is not visible in the picture).

Figure 33 b. Thrombosis of the Central Retinal Vein—so-called Haemorrhagic Retinitis.

Here, the obstruction interferes with the whole venous flow of the retina, so that the haemorrhages are much more numerous and extend over the whole of the retinal area. The veins are very dilated and tortuous, while the arteries are much thinner, and in the disc area rather difficult to see, partly because of the numerous haemorrhages, and partly on account of some slight indistinctness of the tissue, probably due to oedema. In the macular area one can follow the track of the nerve fibres of the retina—the haemorrhages following these in a series of arcs. The disc is only seen with difficulty. It is somewhat reddened, and in parts flecked with linear haemorrhages, and somewhat oedematous. There are no white patches of degeneration visible in this instance, these only appearing at a later stage.

Further examination makes it appear to me probable that the condition shown in this picture 33b, and also the following one is related to some misplacement of the central retinal artery, and the consequent haemorrhagic infiltrations are caused by post anaemic haemorrhages. The reason why the contraction of the arteries and their subsequent closure follows this condition and also that shown in Figure 32, needs still further investigation.

Figure 34. Obstruction of the Superior Temporal Artery of the Retina through Thrombosis, Obliterating Endarteritis or Embolism.

The area of distribution of this branch of the artery in the retina is clouded. The situation of the obstruction is not clearly visible. The interrupted vessels show an almost normal blood content. The cloudiness in the retina caused by the interference in the circulation is most noticeable about the macular region, where it is densest (as is similarly the case, when the central retinal artery is contracted).

Fig. 34.

Fig. 35.

Figure 35. Recurring Haemorrhages in the Retina and Vitreous of a Young Person (Direct Method).

Subsequently there were also vitreous haemorrhages to such an extent, that a view of the fundus became extremely difficult. The cause of the condition remained unknown. No albumen was found in the urine, so that the stellate figure at the macula cannot be put down to albuminuria. One vein travelling in a nasal direction shows white borderings. Several haemorrhages both large and small, are seen in the retina. One large haemorrhage above the posterior pole, (the condition of which is unchanged), has discharged blood down to the macula region, where, remaining fluid, it has formed a horizontal layer. When the head was moved to one side—this collection of blood immediately moved so as to preserve its horizontal level—thus showing that we are dealing with a bag-shaped haemorrhage between the vitreous and the retina.

Figure 36. Syphilitic Disease of the Retinal Arteries.

In the lower left part of the picture, the whole retinal area of distribution corresponding to the affected portion of the artery, presents a clouded appearance and there are numerous haemorrhages. The disease in the walls of the arteries is shown in various places in this area in the form of white lines which accompany the blood column. Here and there, this blood column is quite obliterated on account of the walls of the vessels becoming opaque. At the lower right hand portion of the picture, there are a number of haemorrhages in an unclouded retina, but no vascular changes can be noticed. At the opposite edge of the picture (in the upper left hand quadrant), an artery exhibiting changes in its walls can be seen, but without any haemorrhages or any clouding of the retina. This clouding may not occur until the arterial disease causes entire occlusion of the vessels, and prevents a flow of blood through the collateral vessels. Haemorrhages can occur, even if the disease of the arteries is not visible with the ophthalmoscope. Finally, the walls of the vessels may seem whitened without either cloudiness or haemorrhages occurring in their area.

The anatomical change in the retinal vessels corresponds quite well with those which can be found in syphilitic disease in the arteries in other parts of the body (brain, etc.) such as thickening of the Intima and the Adventitia, first by cellular and later by fibrous tissue, this thickening being sometimes of such extent that the lumen of the arteries is nearly or almost occluded.

Fig. 36.

Fig. 37.

Figure 37. Syphilitic Neuro-Retinitis and Disease of the Retinal Arteries. (Fourteen days after a very sudden onset, one eye only being affected).

At first there was only an appearance of Neuro-Retinitis with well-marked venous hyperemia (corresponding approximately with the condition shown in Figure 12a) and in the macular area there was seen a lightly diffused opacity, together with a small round grey-coloured patch. Vision was entirely absent in the central, the nasal half, and the upper-outer portion of the visual field, and did not return in spite of immediate energetic treatment, and very quickly the condition pictured in Figure 37 developed. In the macular area and around the disc numerous white patches of degeneration were formed (although a urine test showed no albumen), and the walls of the inferior temporal artery exhibited some syphilitic disease in the form of small white scales. The signs of neuritis disappeared at the same time, those of atrophy appearing in their place. The infection had taken place twenty years before.

The disease in the central retinal artery shown here in the form of white scales, is in my opinion a definite characteristic of syphilitic disease of the vessels.

This case shows again, that the stellate figure at the macula is not symptomatic of albuminuria, and it is more probably a general indication of intensive disease of the vessels, with consequent interference in the retinal circulation.

Figure 38. Pigmentary Degeneration of the Retina. (Retinitis Pigmentosa).

This inflammatory condition always affects the two eyes, and since the symptoms of the degeneration are much more noticeable than the inflammatory, the first of the two names given above is to be preferred. This degeneration shows itself in a marked contraction of the vessels which appears in a very early stage of the disease. The arteries and the veins shrink smaller and smaller as the condition developes. In the later stages of the disease, the disc gradually shows a slightly yellowish white appearance due to atrophy. The longer the disease continues, the paler and more grey or leaden hued, does the fundus become, In the commencing stages, the typical dead black pigmented patches appear at the periphery of the retina, increasing in size as the years go on. (This picture exhibits quite an advanced stage). The pigmented patches are always small, sharply outlined, some with saw-like edges resembling bone corpuscles, others star-shaped or occasionally linear or bifurcated, and investing a branch of the retinal vessels. The macular area and the region surrounding the optic nerve, remains free from these pigmented patches longer than any other portion of the retina. The appearance of white patches is never seen. In exceptional cases, some few yellowish white patches of atrophy may develop in the choroid in the later stages (generally out at the periphery), or a few whitish dots may appear in the macular region, also, not infrequently, some later sclerosis of the choroidal vessels is noticeable, in the yellowish or whitish patches of atrophy.

Fig. 38.

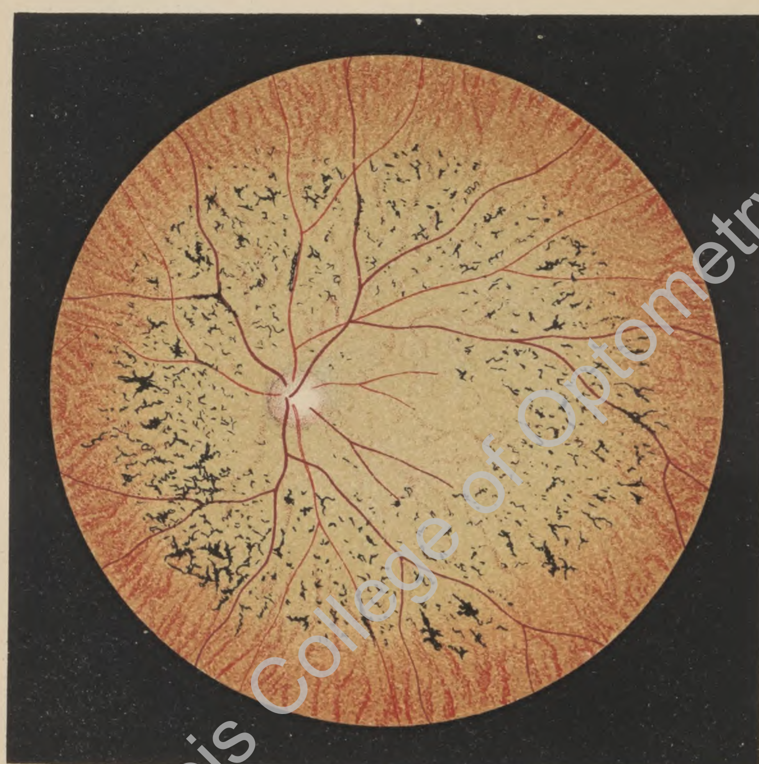


Fig. 39.

Figure 39. Pigmentary Degeneration of the Retina.
(Retinitis Pigmentosa in a more Advanced Stage).

The fundus appearance is much more grey or leaden coloured than in the preceding picture, the pigmented patches are more thickly clustered forming in places a close network, the change in the colour of the disc due to atrophy and the thinning of the vessels, is also more noticeable. The case exhibited the typical characteristics of the visual changes in this disease, the visual field contracting more and more until at last it was reduced to a minimum. As is shown in the picture the outermost zone of the retina kept free from pigmentation. Thus the defect in the visual field was a ring-shaped scotoma which corresponded to the area of pigmentation in the fundus, showing that wherever it was attacked by the disease, the retina ceased to function. It is probable that the pigmentation is but a secondary process, as there may be contraction of the visual field without the corresponding pigmentation.

The microscopical changes of the later stages are shown in Figures 46c and 46d, where the advanced atrophy of the whole retina is much more evident than would appear from the ophthalmoscopic appearance. The section there shown exhibits the entire conversion of the retina into connective tissue, thus losing its normal transparency and explaining the reason for the grey appearance of the fundus in the more advanced stages of the disease.

Figure 40. Disease of the Fundus in Hereditary Syphilis. (Type I.)

This and the following Figures 41 and 42, show differing varieties of the same disease, which like the specific infection in general, as well as in hereditary cases, exhibits varying forms. Whether the primary situation of the disease in such cases occurs in the Retina (pigmented epithelium layer, or that of rods and cones) or in the Choroid, has not yet, in my opinion, been definitely established.

These pictures are inserted amongst the retinal diseases, because apparently the patches of pigment are located generally in the retinal layers, and also because in some cases the condition exhibits some similarity to pigmentary degeneration of the retina, like that described in the preceding figures. In the picture at the lower left portion near the edge, there is an area of a leaden hue with dead black patches of pigment, circular and triangular in shape. The rest of the fundus shows a stippling of fine yellowish red spots. These yellow-red roundish spots stand out in front of a brown mottled background, which almost seems as if it were sprinkled with snuff. The retinal vessels are somewhat small, and the disc is rather pale. For this picture a case was chosen where the condition was well marked. Sometimes the besprinkling is only seen at the periphery of the fundus, and may be much less noticeable and less extensive. If it is well marked, this variegation always indicates hereditary infection. A rather similar, but very much finer mottling of the fundus occurs in conditions of insufficient pigmentation (as in blondes). This latter type is generally only seen by means of the direct method of ophthalmoscopy, the specific type on the other hand can be seen by the indirect method.

Fig. 40.

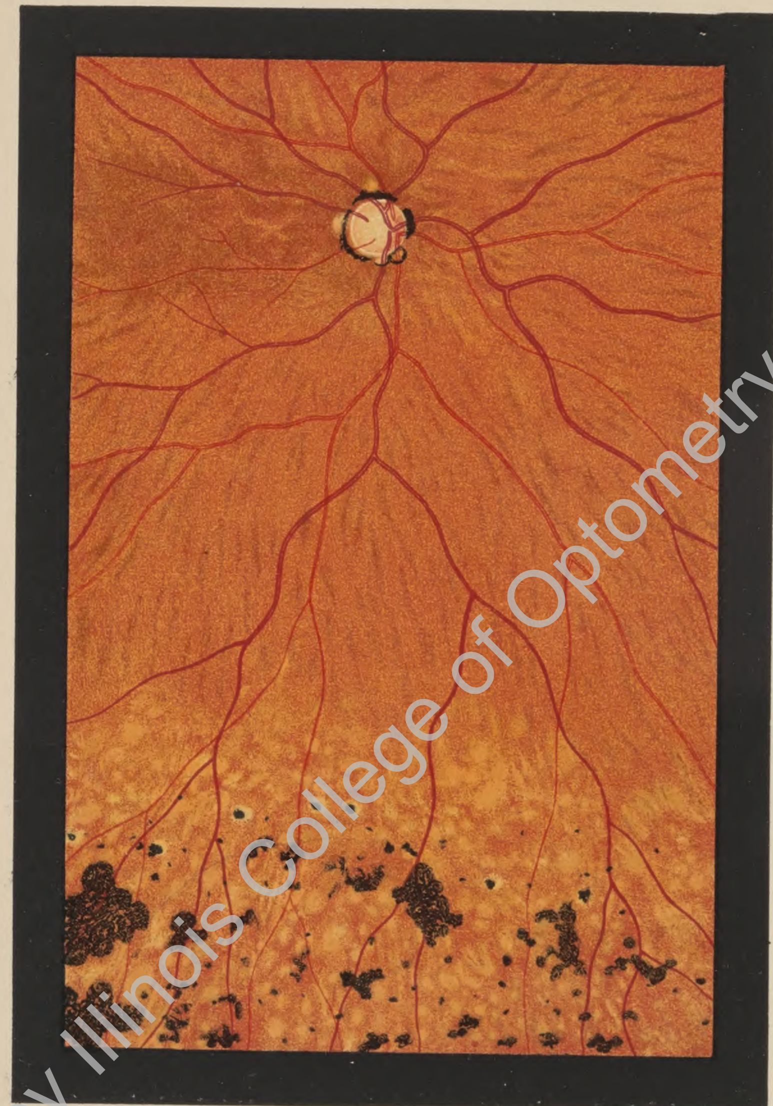


Fig. 41.

Figure 41. Fundus Changes in Hereditary Syphilis. (Type II).

In this case, by no means so advanced as the previous illustration, the disease is often confined, for some considerable time, to the peripheral region. Here also the pigment patches generally lie in the retinal tissue, and are due to disease of the pigmented epithelium layer.

Whether the linear and circular patches of a pale yellow colour are in the choroid or in the pigmented epithelium, cannot be accurately determined. Either situation is possible.

This and the following type of disease are fairly frequently met with, following a diffused interstitial Keratitis, when the fundus is closely examined after the cornea has sufficiently cleared. Sometimes only one portion of the retina is affected, and at other times the whole area seems more or less involved. In this particular case there had been a previous Keratitis.

The dark pigmentation at the margin of the disc seen in all the three types here illustrated may not be seen even in Chorioretinitis, and the theory of Autonellis, that such a marginal pigmentation (Choroidal ring) is a true indication of hereditary syphilis is not conclusive. It may, for instance, be seen in quite healthy eyes.

Figure 42. Fundus Changes in Hereditary Syphilis. (Type III).

Whilst in the former illustrations, the black and grey round patches were both numerous and large, in other cases only white patches are seen, also circular in shape and often intermingled. The largest of these certainly lie in the choroid. This can be noted in this illustration in the case of one oval white patch crossed by a blood vessel. This is certainly a choroidal vessel, and there is, therefore, an absence of choroidal tissue around this portion of the vessel, and the white of the sclera shows through. Undoubtedly the pigmented epithelium of the retina has disappeared from the location of the whitish patches, though there is some suggestion of it at the edges, so that here the retina seems darker than on the surrounding fundus. In this case, there was a previous history of parenchymatous Keratitis.

Sometimes, the types illustrated in Figures 41 and 42 are associated with each other, so that one sees at the periphery both dark and light patches, often mingled with each other, and sometimes, here and there, small red and yellowish spots on a brown speckled background, with a sprinkling of small patches of pigment of the type shown in Figure 40.

Generally, all three types of hereditary syphilitic disease in the retina, which are here illustrated, exhibit a formation of some patches around central foci, and these later intermingle and form quite irregular patterns.

Fig. 42.

Fig. 43.

Figure 43. Secondary Pigmentation of the Retina with Disseminated Choroiditis.

The central portion of this picture is somewhat similar to the appearance of a case of pigmentary degeneration. The disc area is of a lighter tint than usual, the vessels are rather smaller, and the fundus itself is slightly lighter—being somewhat yellow-grey in colour. In this same central portion are to be seen tiny pigment patches, exactly like those found in pigmentary degeneration. There are also seen, however, several large white patches, sharply defined and circular in shape, and almost entirely situated near to the periphery. These indicate patches of sclera now visible, because the pigmented epithelium layer of the retina and also the choroidal structure has disappeared at these places, they being the site of the foci of choroidal inflammation, and are typical of disseminated choroiditis. There is nothing remaining at these patches of the choroid except occasional choroidal vessels running across them like thin red ribbons. In several of these atrophied portions of the choroid, even the vessels are lacking. One spot shows at its centre a small pigment patch. This type of chorioretinitis, an advanced stage being shown in the case illustrated, is often complicated by some vitreous opacities and is frequently a result of acquired syphilis.

Such secondary pigmentation of the retina also follows other types of choroiditis if the inflammation is severe and of long standing, as will be seen in subsequent illustrations.

Figure 44. Disease of the Macular Area of the Retina following High Myopia.

The changes shown in these two figures have been sometimes called *choroiditis postica*. I am of the opinion, however, that the seat of the disease is mostly in the posterior layers of the retina and the pigmented epithelium, although the choroid becomes more or less affected in most cases, in the later stages. One fact strongly supporting this opinion, is, that very slight changes in this area, through myopia, are immediately complicated by strong visual disturbances, whilst, by contrast, in disseminated choroiditis there may be very noticeable changes in the choroid behind the macular area, without the effective function of the retina suffering in any way. It cannot be denied, however, that in certain particular cases the disease occurring with myopia may commence in the choroid and manifest itself almost entirely in that membrane.

The macular condition is of the greatest importance, since it causes a depreciation of vision in a great many myopic eyes. It shows differing appearances as is shown in these and the following Plates. Figures 44 a and b and Figure 45 a, all depict not very advanced stages of the disease. In Figure 44 a, the disc is surrounded by the ring-shaped choroidal defect, which is symptomatic of myopia, and in 44 b is seen a similar crescent-shaped defect of the choroid, together with some pigment markings. In 44 a, there is seen in the macular area, a delicate spotting or marble-like appearance, which is associated with early stages of the disease. Traces are also seen of irregular pigmentation, which soon became more marked in appearance. There are also a few small haemorrhages visible. In 44 b, the marbled appearance is more noticeable, as is also the irregular deposition of pigment. Generally the fundus shows a paucity of pigment, so that, as is frequently the case with myopia, the choroidal vessels are easily distinguished, standing out brightly on the darkened background.

a Fig. 44. b

Fig. 45.

Figure 45. Disease of the Macular Area of the Retina, following a High Degree of Myopia.

In Figure 45 a, some reddening and a slight swelling of the disc is evident on the nasal half, which appear, in such a condition, following prolonged strain, and are probably indicative of a functional hyperaemia, though many are of the opinion they indicate inflammatory conditions. The shape of the disc is somewhat distorted, and is encircled by an atrophied patch of choroid, in the form of a "meniscus" or "cone." The fundus area is only sparsely pigmented. The macular disease shows as yellowish red spots and some irregularity in the pigmentation, especially in the middle of the fovea, where there is a dark pigment spot surrounded with slight haemorrhages.

Figure 45 b shows a rather more advanced stage of the disease. Here is seen a marked increase in the pigmentary changes, and there are some whitish spots which show that the choroid is also affected, and through the atrophied patches, the white of the sclera is visible. Some of the pale yellowish patches extend up to the atrophied crescent at the margin of the disc.

Figure 45 c shows a very advanced stage of macular disease, where it is quite evident that the choroid is involved. The margin of the disc is atrophied in the form of a complete ring, which is broadest on the side of the macula. At the macular area there is a large white patch, with arc-shaped edges, occasionally outlined with pigment. In this space the choroidal tissue has quite disappeared, with the exception of a few choroidal vessels and some traces of pigment. Further to the temporal side, there is a still larger patch (which extended right up to the equator) of atrophied choroid and retina, covered with irregular accumulations of pigment patches.

Figure 46a. Secondary Pigmentation of the Retina caused by a Fragment of a Percussion Cap (not to be seen in the picture) which remained in the eye for twenty years.

This a posterior section of the globe as seen from the front. At the centre the optic nerve is seen from which the retinal vessels spread out. In the left half of the figure, the retina is seen to be detached from its foundation (whether it was so during the patient's lifetime—or is a fault in preparing the section cannot be determined). In the region of this detachment, there is shown, better than in other parts of the fundus, a defect in pigmentation, which is very similar to the pigmentary degeneration seen in retinitis pigmentosa (c.f. Figures 38 and 39). This section also shows very strongly those advanced changes in the retina, the ophthalmoscopic appearance of which can be seen in Figure 74, which also illustrates the visible changes caused in the eye by a piece of percussion cap. (This latter patient when examined later, exhibited an even more marked degree of retinal pigmentation than was visible at the time when the picture was drawn.)

Figure 46 b. Cross Section through an Eye with an old standing, total or Funnel-Shaped Detachment of the Retina.

The retina projects forward in a bandlike formation, broadening in front and still containing degenerated vitreous body debris, and surrounding the lens. Between the retina and the choroid, there are irregular patches of exudate.

Figure 46 c. Pigmentary Degeneration of the Retina. (Retinitis Pigmentosa.)

In this illustration, a very advanced stage of the disease is depicted, such that the normal retinal structure is quite absent, this being converted into a fibrous membrane, interspersed with nuclei and pigment patches, the rods and cones having entirely disappeared. The choroid is quite normal.

Magnification 30 times.

Figure 46 d. A Portion of the same Section under Higher Magnification.

The pigment is seen to be accumulated around the retinal vessels in accordance with the ophthalmoscopic appearance.

P. Pigment in the Retina. Magnification 78 times.

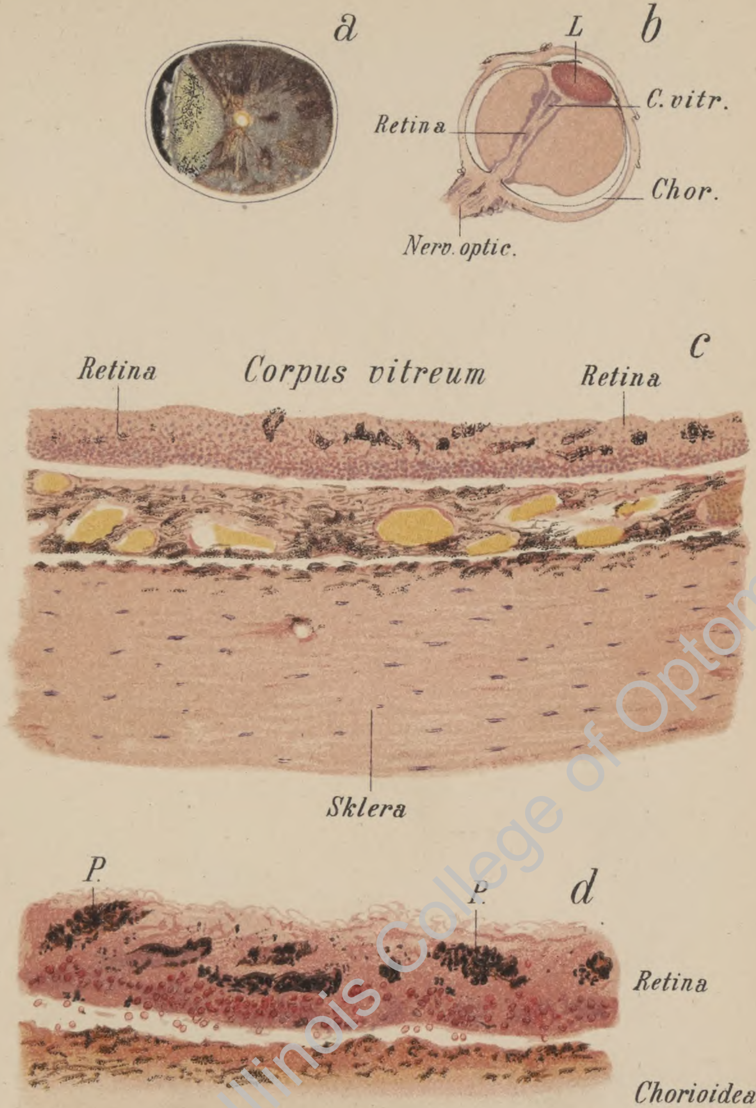

a
L
b
C. vitr.
Retina
Chor.
Nerv. optic.
c
Retina
Corpus vitreum
Retina
Sklera
P.
P.
d
Retina
Chorioidea

Fig. 46.

1 2

3 4

Fig. 47.

Figure 47. Disease of the Macular Area of the Retina due to Old Age. (Senile Macular Disease).

The amount of visual disturbance in this disease, is much more marked than the visible pathological changes would seem to warrant, showing that the sensory and pigmented epithelium layers of the retina are the first to be affected. In some cases the affection may involve the choroid lying immediately behind, as is the case in Figure 47-3, where the condition is shown three months after the commencement of the trouble, and inset the appearance of the affected area six months later. The disease, which usually attacks the two eyes, is quite incurable and causes a marked diminution of vision, in spite of the only visible fundus changes being, either a light or a dark mottling caused by yellowish red or yellow spots or some increase in the pigmentation, these always being most noticeable at the fovea. Figure 47 shows only a few examples, which do not typify all the different appearances of this disease. In all the cases shown the remainder of the fundus appeared to be normal, except, perhaps, some slight senile discolouration of the disc or senile pigmentation at the periphery of the retina, in the form of black dots arranged in rows or irregular groups (c.f. Figure 72). The hyaline bodies (drusen) of the vitreous layer of the choroid which are shown in Figure 72, are also evidence of a senile change, but must not be confused with the macular disease which is here being described.

Figure 1 shows the maculae of the two eyes of a patient aged seventy, and Figure 4 those of another aged seventy-four.

Figure 48. Disease of the Macular Area of the Retina, following a blow on the Eye (Traumatic Macular Disease).

The after affects of some violence on the globe, such as (1) a fall on to the eye (2) and (3), a blow from a fist, (4), a blow from a hammer (of twenty years' standing), the packing of a blank cartridge, an arrow, or a blow from a whiplash, etc., are shown at the foveal region of the retina by the appearance of some barely noticeable changes, which, however, result in very grave and incurable disturbances of vision, and which are frequently of very great importance from a medico-legal aspect, as compensation cases. The changes in marking and pigmentation, are often very trifling, especially at the commencement, and they may continue to remain so, or may be evidenced as some distinctly pale patches, as for instance in Figure 48, 4. At times merely a slight loosening of the pigmentation becomes evident in the middle of the foveal region, and is restricted to a very small area, being similar to that seen in myopic and macular changes associated with old age, whilst in cases of Berlin's traumatic opacity of the macular area (c.f. Figures 51 and 52), these spots disappear, in this disease they remain. One should not conclude that anyone complaining of loss of vision after such a blow may be a malingerer until the pupil has been dilated, and the macular area of the injured eye inspected and compared with that of the other eye. The disease, frequently does not become evident for some weeks.

1

2

3

4

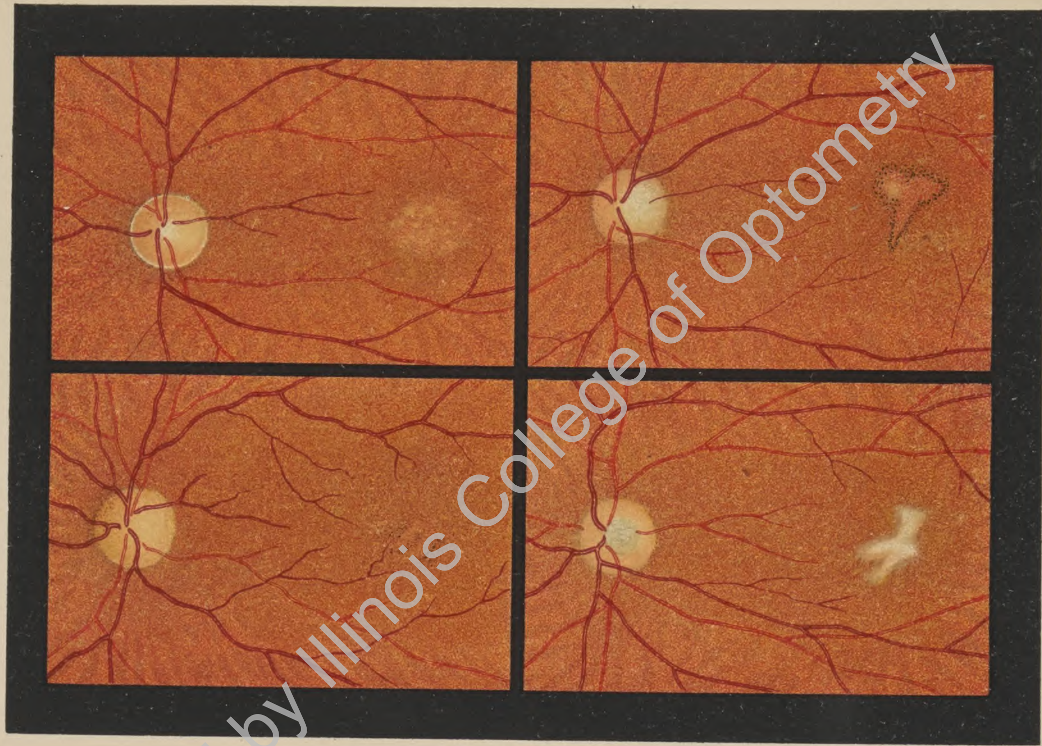


Fig. 48.

Fig. 49.

Figure 49. Perforation of the Macula after Contusion of the Eyeball.

The case was a fifty-two year old man, who some ten years before had a stick thrown at his left eye. Ever since the occurrence, the vision of this eye had suffered, and at the time of my first examination, when this fundus picture was drawn (1891) he could only count fingers at a distance of 1·5 metres. At the centre of the macula, there was a circular perforation with clear cut edges, in size half the diameter of the disc, and surrounded by a faint opacity, lightly stippled, and in places covered with pale glistening dots and patches. Some of these latter are also visible against the characteristic red colour of the defect in the retina, the floor of this perforation being uniformly of this red colour, showing by the direct method a very faint stippling, only visible with some difficulty, and indicative of the mosaic-like arrangement of the pigmented epithelium. The rest of the fundus appeared to be normal.

Defects of such a nature are frequently seen after severe contusion of the globe, after blows from a stick or a fist, stones, etc., or explosions, arrow wounds. The perforation is generally circular, but may be oval in shape, consequent upon some shrinking and deterioration of the retina in the macular region.

Such foveal perforations may appear quite spontaneously, in cases of advanced age, without any wound causation, and possibly may be a result of arterio-sclerosis. The author has observed, in one such case, perforation in the two eyes of a woman sixty-four years of age, and having also marked arterio-sclerosis and some albuminuria.

Figure 50 a. Section through the Macular Area in Macular Disease resulting from an Orbital Tumour.

The section was made from the eye depicted in Figure 54a, after enucleation. The yellow-red patch with pigmented edges seen in this latter picture, is indicated in the transverse section, by some defect of the pigmented epithelium in the foveal area, due to absence of the pigment, or even lack of the epithelial structure itself.

Similarly, the cones with the corresponding nuclei are also absent in certain areas. There is a marked change in the nerve fibre and ganglionic cell layers. In this latter layer, the diminution in the number of cells and the formation of hollow spaces, is very noticeable. (c.f. Figure 14 c of the normal macula). The choroid exhibits no very marked changes.

Magnified 30 times.

Figure 50 b and c. Transverse section through the Retina in Thrombosis of the Central Retinal Vein. (c.f. Figure 33 b).

Section " b " depicts the neighbourhood of the disc, whilst section " c " is at a position more remote. Thus in " b " is seen a larger retinal vein very much engorged (Ret. V), whilst in " c " a larger number of smaller vessels are shown, all, however, more or less engorged through the holding back of the blood. Additionally, one sees large and small haemorrhages distributed all over the section. In " c " many hollow areas and fissures are seen in the tissue, which must be a consequence of oedema.

1. Nerve fibre and ganglionic cell layer. 3. Inner Nuclear Area.
4. Outer Reticular Layer. 5. Outer Nuclear Layer.
6. Layer of Rods and Cones.

Sections " b " and " c " magnified 90 times.

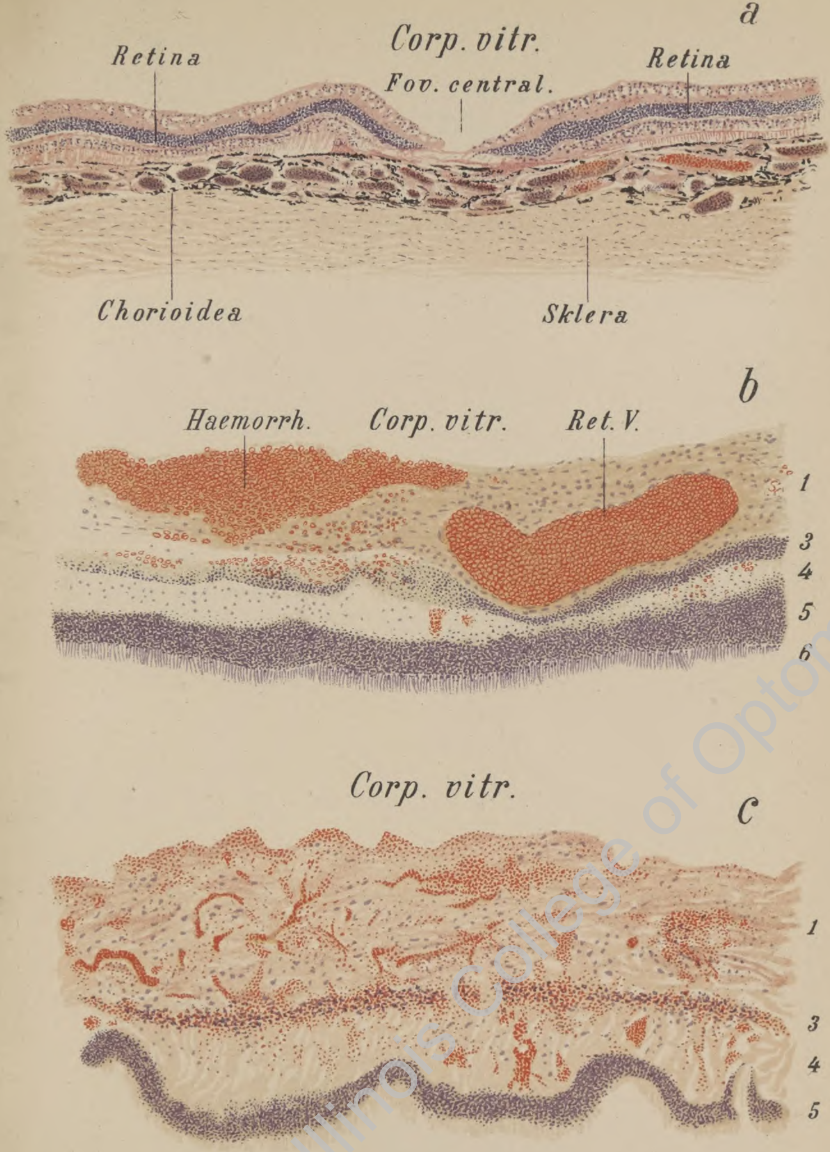

a
Corp. vitr.
Retina
Fov. central.
Retina
Chorioidea
Sklera
b
Haemorrh.
Corp. vitr.
Ret. V.
1
3
4
5
6
Corp. vitr.
c
1
3
4
5

Fig. 50.

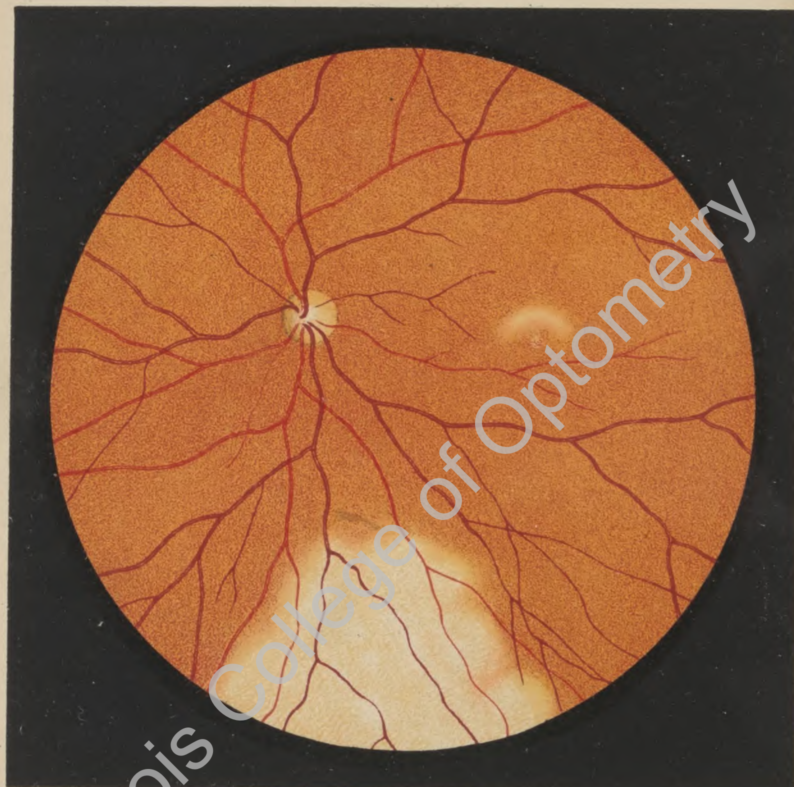


Fig. 51.

Figure 51. Opacity of the Retina, due to a blow on the Eye ; Berlin's Opacity ; Commotio Retinae. (Direct method reduced).

This type of opacity, often seen after an external blow on the eye with some blunt instrument, was first described and studied by Berlin. The changes rapidly disappear, and so are best seen, if an examination is made, immediately after the injury. The opacity is often produced by a blow with a fist or a stick, a sharp knock or blow from a stone or a snowball, etc. Often a milky-white opacity is seen in two widely separated portions of the retina, one at the place where the blow was struck, and the other generally situated in the macular area. The former is, as a rule, larger, more clearly defined, and remains for a longer time, whilst that in the macular region is less intensive and quickly disappears. The macula and the visual acuity remain unaffected. The opacity near to the periphery does not usually occlude the blood vessels. The condition has frequently been confused with detachment of the retina. The nature of the opacity is not, as yet, well known. This particular picture was drawn a few hours after a blow from a snowball.

Figure 52. Opacity of the Retina due to a Blow on the Eye : Berlin's Opacity : Commotia Retinae.

In this case there was a much more severe contusion of the eye, it having been struck with a large piece of iron, and, in consequence, the opacity of the retina was more marked, and some small haemorrhages are seen in the area of the actual injury (the upper edge of the picture, and so the lower portion of the globe). The unusual appearance entirely disappeared in a few days, first of all, the opacity in the macular area, and then, that in the lower portion of the retina. This traumatic opacity is easily differentiated from cases of detachment of the retina. In addition to the fact that a newly detached retina is more transparent, rather than this milky white colour, in *commotio retinae*—the track of the retinal vessels are undisturbed, and there is no parallactic dislocation or evidence of any hypermetropia. Also the fold-like appearance of a retinal detachment is absent.

Fig. 52.

a

b

c

d

Fig. 53.

Figure 53. Disease of the Macular Area due to the presence of a Foreign Body in the Vitreous.

The extreme sensitiveness of the macula is shown by the fact that foreign bodies, even if aseptic, penetrating into the interior of the globe, often cause, in a short time, some isolated disease of the retina in this area, without direct injury to the macula itself. Four such cases are shown in Figure 53, where the small grey white spots seen at the centre of the macula in " a " were caused by a particle of a copper cartridge case, which remained for five days in the vitreous. These spots entirely disappeared after the particle had been removed, and two and a half months later vision returned to normal.

Figure " b " depicts a yellowish discolouration of the macular area, as seen a year after a particle of copper (from a fuse cap) had entered the anterior portion of the eye, and which was not removed, and ultimately produced the changes shown in Figure 74, which shows a much later stage.

Sometime later, this discolouration decreased somewhat, and at the time of writing, seventeen years after the actual injury, visual acuity was still 1/3, this being very exceptional.

The roundish grey spot which is shown in Figure " c " was the result of a splinter of steel which remained in the retina for twenty hours. The actual splinter which is shown in Figure 55a, was drawn back into the anterior portion of the eye by means of a giant magnet and eventually removed. First of all, the macula showed some yellowish pigmentation, succeeded by the dark grey spot shown in the picture, which was painted three months after the actual injury. The visual acuity of the eye was reduced to 1/10, but otherwise, the condition of the eye was unaffected. The slight pigmentary change shown in " d," followed the presence of an iron splinter from a hook which remained in the vitreous for eight days, and was then removed with the aid of a small magnet. This injury reduced the visual acuity to 1/7.

Figure 54. Disease of the Macular Region produced by Pressure and Contusion of the Globe from within the Orbit.

"*a*" In this case, a marked protusion of the globe had been gradually caused by a slow growing angioma. The disc area is reddened and swollen, the retinal veins are distorted and congested, and in the macular region one sees a large yellowish red patch, fringed with a dark discolouration. Since the eye had to be removed, there was opportunity for anatomical examination Figure 50 *a* exhibits the marked changes which had occurred in the foveal region.

"*b*" A pistol shot through the temples had destroyed the right eye and injured the left, as shown in this picture, which was drawn six days after the injury. The bullet had grazed the left orbit, and caused a concussion, and some amount of contusion to the globe from behind. In the macular area, the most noticeable changes are evident. where can be seen haemorrhages, a few pale washed out patches, and some irregularities of pigmentation. Below the disc (above in the picture) there is a pale longish patch and two small haemorrhages. Another small haemorrhage was seen near to the disc at the first examination, but later was absorbed.

a Fig. 54. b

a Fig. 55. b

Figure 55. Recent Injury to the Retina by an Iron Splinter.

In the case " a," some twenty hours before this picture was drawn, the splinter had entered through the sclera, just on one side of the cornea (whilst the patient was working on a lathe), and later, was seen in the retina. Its position was not altered if the eye were moved, and after the removal of the splinter, very marked changes were noticed at the place where it had been embedded. The removal of the splinter from the eye was effected by means of a giant magnet, immediately after this drawing had been made. The injury was followed by macular disease, although the splinter had not touched this area (c.f. Figure 53 c).

The same kind of thing happened in case " b," where the splinter entering through cornea, iris and lens (whilst the patient was welding pieces of cast steel), was also embedded in the retina. As in the first case, the part of the retina surrounding the particle, was covered and infiltrated with blood. The metallic sheen of the iron and its black colour were clearly seen with the ophthalmoscope, and an attempt has been made to illustrate this appearance as closely as possible in the pictures. The whitish spots, on the foreign body, are the effect of reflections, and not to exudates such as are seen in the next two cases. After removal, the splinter in Figure " a " was measured and found to be 4 mms. long and 1·5 mms. in diameter. The longitudinal edge showed up very sharply when seen with the ophthalmoscope. The splinter shown in case " b " was rather shorter and had a weight of 0·016 grammes.

Figure 56. Air Bubble in the Upper Portion of the Vitreous, following the entry of an Iron Splinter. (Direct method reduced).

Shortly before the picture was made, whilst working with iron, this mishap had occurred, and the metal splinter had become embedded in the lower portion of the retina. The air bubble formed just after the entrance of the particle, and disappeared in a few hours. These air bubbles vanish very rapidly, and thus can only be seen immediately after the injury has occurred. Several such bubbles may be seen in the vitreous body after the entry of a splinter. Thus the presence of air bubbles in the vitreous is of diagnostic importance, indicating injury, by means of a foreign body, within the globe. Sometimes, though very rarely, injury to the globe by such a splinter, even if it does not remain in the eyeball, may be followed by the entrance of air bubbles into the vitreous, so that the presence of such bubbles, although indicating a strong probability, does not absolutely indicate the presence of such a splinter.

These air bubbles in the vitreous have just the same appearance as air bubbles in a microscopic section. In this particular case, the splinter was immediately removed by means of a giant magnet, and complete restoration of vision resulted. The appearance in the picture of a retinal vessel passing over the surface of the foreign body is an error in the colour printing.

Fig. 56.

Fig. 57.

Figure 57. An Old Injury to the Retina by an Iron Splinter.

Whilst in both of the preceding cases, the foreign body had only been *in situ* in the retina for a very short time, and was clearly visible on the surface of, or embedded in, the retinal membrane, this present illustration depicts two cases, where the splinters had entered some considerable time before, and they now show a very different appearance. Here the foreign bodies are covered with a white exudate, the black colour of the metal only being seen in two places in Figure "a" where the splinter, which had remained in the retina for two months, had caused typical changes in the surrounding area. The pigmented epithelium layer has to some extent disappeared, and the splinter is encircled by a lightish coloured area, in which some choroidal vessels are clearly visible. This area also posesses some irregular pigmentation, in the portion nearest to the foreign body. Nearby can be seen three small choroidal patches of lighter colour, with indistinct margins, and surrounded by some irregular pigmentation.

In case "b," no such changes are shown in the area immediately surrounding the splinter, although it had been in the retina for six weeks prior to the time at which this picture was drawn.

Figure 58 a. Point of Impact of a Foreign Body, shown in the Fundus. (Direct Method).

When a foreign body enters the eye with considerable velocity, such as for example, a fragment of a metal fuse cap, or a splinter from an axe, it may pass through the entire globe, and on striking the tissues seen in the fundus picture, rebound into the more anterior portion of the vitreous body, where one must look for it, Sometimes, it may be in the lower portions of the ciliary body, where it cannot be seen. In such cases, it is of importance that the point of impact, as seen in the fundus, is carefully examined, so that the diagnosis of the presence of the foreign body in the globe, can be made with reasonable exactitude. One can recognise this spot, if the splinter has passed through both retina and choroid, by its whitish colour, and usually circular shape, since the white sclera becomes visible. The margins of the wound are often tinged with blood, and from this spot, in certain instances, some blood may exude into the vitreous, as is the case here illustrated, so that the entire area becomes more or less obscured. The blood in the vitreous forms a darkish cloud, which, in some cases, appears to be sunken. In this particular case, the impact was from a splinter from an axe.

Figure 58 b. Retinal Bands due to Traumatism. (Retinitis Proliferans).

These appeared after severe contusion of the eye, which caused scleral laceration at the nasal edge of the cornea, prolapse of the lens and strong haemorrhage into the vitreous. The fundus, on examination after the haemorrhages had subsided, showed a number of narrow grey-white strands surrounding the disc, in places obscuring the vessels, and disappearing at some distance from the disc. There was no detachment of the retina. Anatomical examination of this globe, at a later date, showed that these grey-white strands, or cords, were the result of a peculiar proliferation in the most anterior layers of the retina.

a Fig. 58. b

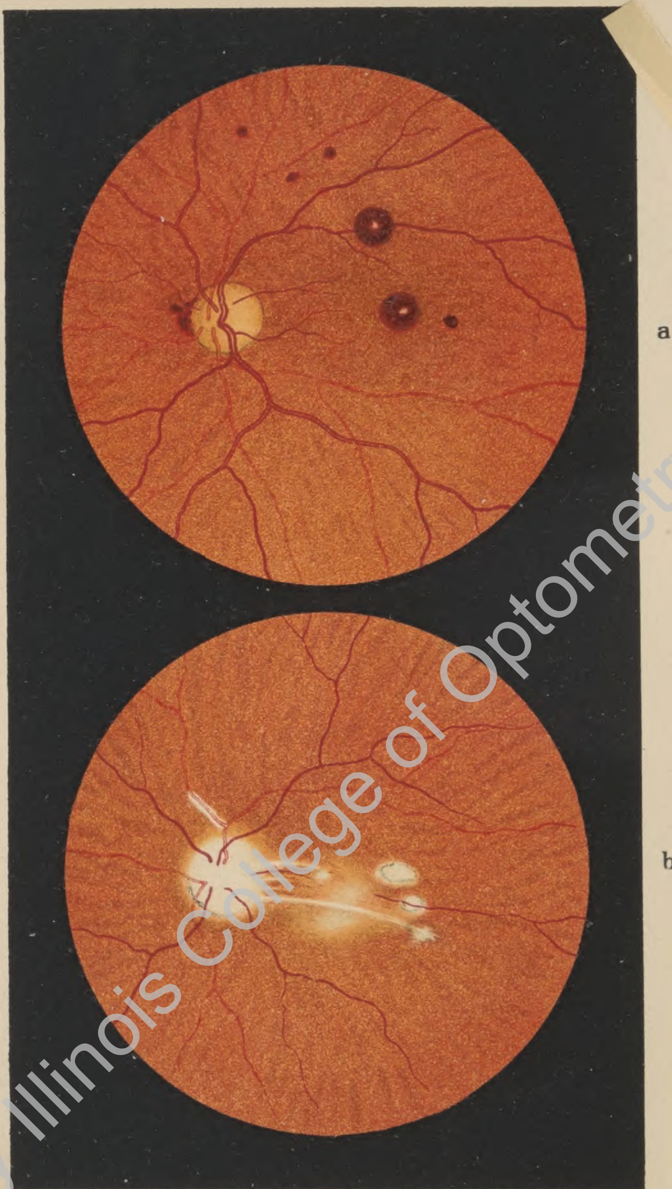


Fig. 58. I

Figure 58 I. Fundus Changes following difficult cases of Labour, with Delivery by means of Forceps.

(a). Retinal haemorrhages in the right eye of a child delivered with the aid of forceps, which as soon as it was awakened from heavy asphyxia, showed in both eyes conjunctival haemorrhages and corneal opacities. The latter were strongly marked in the right eye, and a continual stream of blood could be observed in the anterior chamber. Furthermore, there was left facial paralysis. About four days later, the right cornea had cleared, and the haemorrhages in the fundus could be observed, of which the smaller ones clearly lay in the retinal membrane, but the two larger spherical ones lay well in front of the retina—between it and the vitreous body, and in the middle of each, a bright reflex was to be seen. One was immediately in front of the macular area. The haemorrhages eventually disappeared, and on examining the child four and a half years later, the fundus seemed normal and visual acuity was good.

(b). Atrophy of the Optic Nerve and of the Retinal Vessels with disturbance in the Macular Area and Strands of Connective Tissue in the Vitreous Body. This eye was the left one of a forty-nine year old woman, and it diverged strongly, and was totally blind. The patient stated that at her birth (with delivery by forceps), the left eye was entirely outside of the orbital cavity. At the time of examination, the disc showed the dead white colour of total atrophy. The retinal vessels were small, especially the arteries, of which the nasal superior branch showed a portion with white atrophied walls. The macular disturbances are exhibited as a bedaubed looking yellowish patch and two roundish areas, at which the choroidal tissue appears to be deficient. Stretching from the disc to the macula, a bright streak is seen, which terminates in a bright spot. A similar bright streak projects from the disc into the vitreous, this also being on the macular side of the disc. It is quite evident that we are here shown the consequences of a very severe contusion of the globe, with rupture of the nerve.

Figure 59. Retinal Detachment in the Temporal Portion of the Fundus.

Although it is of twelve weeks' standing, this may be described as a recent injury, since, as yet, there is no very marked opacity or wrinkling of the tissue. The absence of choroidal striations in the area should always be noticed, this being typical of the appearance of retinal detachment, they being hidden by a slight opacity of the retina, and also by subretinal fluid. This opacity is densest where the retina is thickest, that is, at the marginal zone of the macula, so that at the fovea, where the thinnest portion of the retina exists, there is, by contrast, a brighter red appearance; on the other hand, here the red colour of the choroid shows through more strongly, much more so than in other types of macular opacity, because the retina in the foveal region is thinned by the atrophy of its elements. Sometimes, in cases of retinal detachment of some duration, one can perceive a perforation just at the centre of the fovea.

The detachment, which here is situated in the temporal quadrant of the fundus, is only superficial, that is to say, not very far distant from the choroid. In the macular area, there is hypermetropia of 4·0 D, and more towards the periphery from 7·0 to 8·0 D, whilst the disc area is emmetropic. Vision was reduced to the counting of fingers at a distance of three metres.

Fig. 59.

Fig. 60.

Figure 60. Retinal Bands and Retinal Detachment after a Punctured Wound of the Eye.

Four years after a trifling injury to the eye from a spicule of brass, which had pierced the sclera on the temporal side of the cornea, a diminution of visual acuity became evident. As the picture shows, there was to be seen in the outer upper quadrant, between the corneal margin and the equator, a greyish-white spherical mass of exudate, projecting forward somewhat into the vitreous, and shown at the left-hand edge of this picture. Below this mass of exudate, which represents the position of the puncture, (and touching it at the upper edge in the picture) the retina was detached, and the detachment extends along the entire upper border. Wherever the retina is so detached, it shows a lighter colour, and folds can be seen, together with irregular and twisted vessels, rather darker in colour than the rest of the vessels. Between the detachment (in the lower portion of the eye), and the mass of exudate, a number of white bands or lines are to be seen, some of which anastomose, and generally they are all running in one direction. In the neighbourhood of these lines, the retina is not detached. One cannot say if these bands are similar in character to those illustrated in Figure 58 b. They remained unchanged for several weeks. The macular area exhibited unusally dark and somewhat irregular pigmentation. The detachment would probably increase still further later on.

Figure 61. Retinal Detachment at the Inner Upper and Inner Lower Portions of the Right Eye. (Indirect Method).

At the inner upper portion, there is a small rent in the detachment, through which can be seen the red colour of the choroid. Towards the nasal side, one stretch of retina is not yet detached. Above and below this patch, the detachment is very marked. (Later, it increased still further in spite of treatment). The detachment in this case was of three months' standing, and had commenced quite suddenly. Thirty-five years previously, the patient had been operated upon in both eyes for lamellar or congenital cataract (in the left eye with a closed pupil), and he saw quite well with the right eye up to the present time, although aphakic. A fine band in the anterior portion of the vitreous, otherwise quite clear, seemed to indicate that there was some injury to the vitreous, with prolapse, at the time of the operation.

This case is an excellent example of the dangers of injury to the vitreous, and also shows how the retinal detachment, thus induced, may be long delayed under certain circumstances—in this case—for as long as thirty-five years.

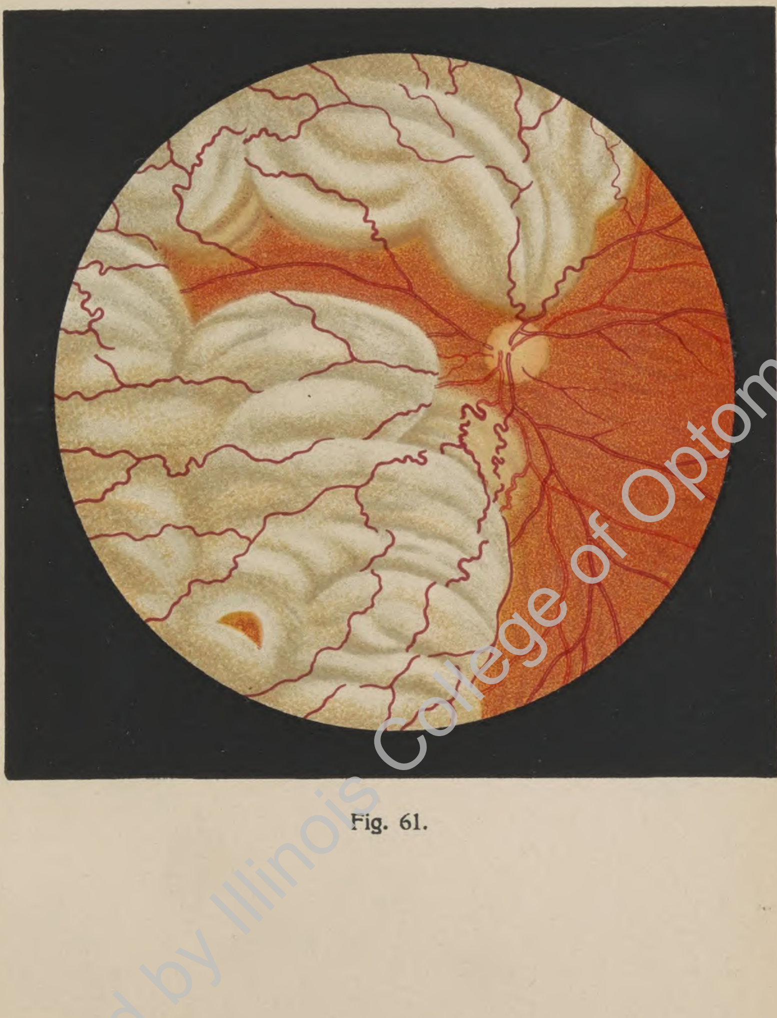


Fig. 61.

Fig. 62.

Figure 62. Retinal Detachment (Solutio Retinae) with Laceration.

Quite often in detachment of the retina, a rent or a hole of varying shape and size can be seen in the detached portion, and in many cases, the opening is surrounded by a shred of the membrane corresponding in shape, which seems to have been torn out and then reflected back or puckered around the opening. Thus, in this case, a tongue-shaped piece of retina stretches from the lower portion of the picture towards the red opening, approximately quadrilateral in shape, which lies in the centre of the detachment and of which it forms the lower edge. This has probably been torn out of the detachment and so produced the opening. According to Leber, the vitreous body as it shrinks, tears the retina away from the pigmented epithelium, and at times produces an opening, which will correspond to an area where the attachment to the retina is more firm). Through the opening, the edges of which are somewhat rounded, the vascular striation of the choroid is seen, and which is also clearly visible in the upper portion of the picture, where the retina is normal and transparent. To the left of the picture, the detachment shows signs of extension. Here the condition is quite superficial. The disc lies invisible behind the area of detachment.

Figure 63. Haemorrhagic Retinitis of Pregnancy.

In spite of the presence of the stellate figure in the macular area, repeated examination of the urine disclosed no albumen. Delivery was effected at the proper time, and within three weeks, this disease which affected the left eye only, spontaneously disappeared, the whole accumulation of haemorrhages and white patches of degeneration, which are to be seen in the picture, vanishing completely, although the woman was very anaemic, both before and after the delivery. Visual acuity became quite normal again. The right eye was unaffected. Possibly we are dealing here with a partial thrombosis of the central vein (which only partly closed the bore of the vessel).

Fig. 63.

Fig. 64.

Figure 64. Retinitis Circinata. (Described and so named by Fuchs).

This was seen in the right eye of a seventy-seven year old man, who was otherwise quite healthy—the other eye being normal.

Around the macula, in the shape of an oval, there are seen glistening white patches, some separate and others agglomerated, and in colour very reminiscent of those seen in albuminuric retinitis and diabetes. Near to where these broaden like a girdle, are strewn a number of isolated white patches and dots, which look almost like crystals. Here and there, amongst the white patches, or adjoining them, small round haemorrhages are to be seen. The retinal vessels, which show no changes in their ophthalmoscopic appearance in this disease, travel uninterruptedly over the white patches. The macular area is somewhat dull in appearance, and the foveal reflex is absent. The visual acuity is reduced to 1/50, and, therefore, further evidences of disease can be suspected in the microscopic appearance. Near to the centre of the fovea, there are a few pale and one darkish spot, the latter lying in the pigmented epithelium layer. In other cases, more marked changes in the macular area were noticed, and comprising indefinite yellow or yellowish-grey, irregularly shaped patches.

The rest of the fundus is normal. At the temporal edge of the disc there is a small crescent, although there was no myopia present.

Figure 65. Fundus Changes in Leukemia.

This is a case of spleno-medullary leukemia, with enormous enlargement of the spleen—seen in a young patient of Professor Eichhorst's. The trouble commenced one and a half years before. As yet, there was no complaint of defective visual acuity. In spite of the large increase in the number of white blood corpuscules—the fundus does not appear unusually pale, the periphery seeming even somewhat dark, owing to strong pigmentation. The outstanding feature is the similarity of colour of the retinal arteries and veins—the latter being only discriminated by their excessive tortuosity, and their increased breadth. Furthermore, on account, to some extent, of the pale colour of the blood, the retinal vessels seem almost white in colour, an additional cause for this appearance being the changes in the walls of the blood vessels, especially at the periphery, where can be seen tiny light and darkish dots and a few larger pale patches, and also two haemorrhages with lightish centres. Around the disc and the macular area, there is some cloudiness of the retina. The disc itself is obscured, being not only clouded, but paler than normal.

These changes were equally noticeable in the two eyes.

Fig. 65.

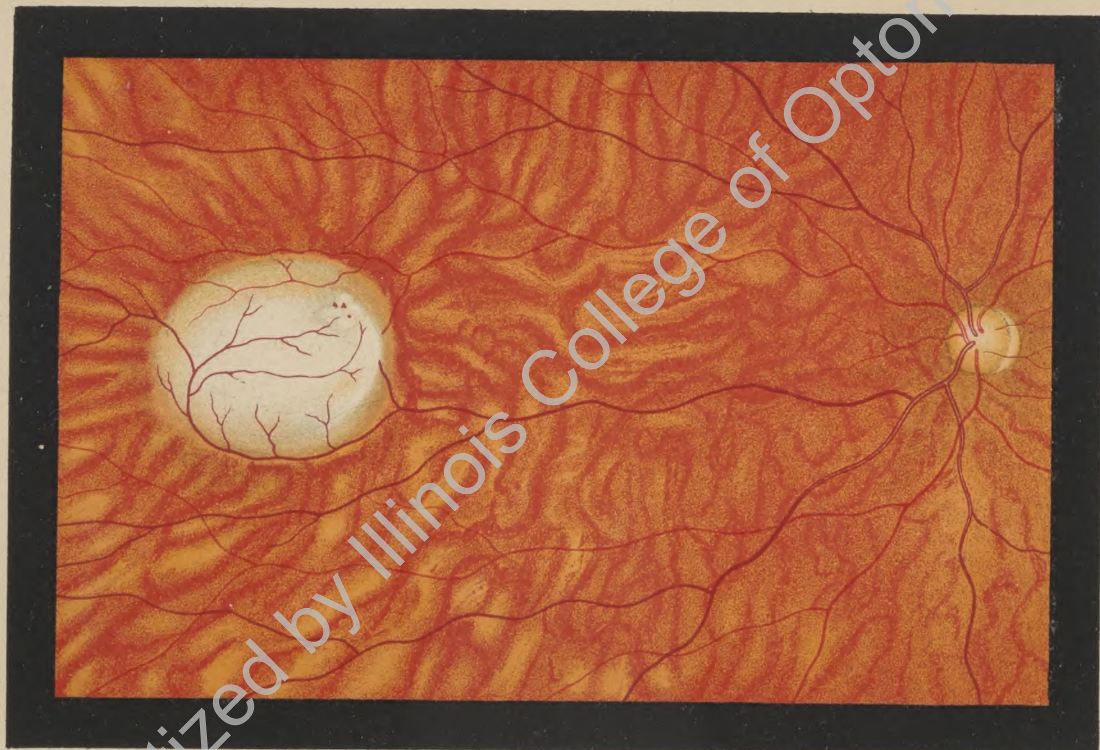


Fig. 66.

Figure 66. Glioma of the Retina.

The boy aged two and a half years, from whom this picture was drawn, was brought for observation with a very advanced gliomatous proliferation in the left eye. A thorough examination of the right eye disclosed a very small glioma in the nasal half of the fundus—which looked like an oval greyish nodule, with a rather irregular, although roundish surface. The growth was clearly outlined, and the surrounding areas were unchanged. The rest of the fundus seemed normal, with little pigmentation, allowing the choroidal vessels to be freely seen.

Although this nodule increased very slowly, that in the other eye probably spread to the brain, so that death ensued at the age of three and a half years.

Figure 67a, explains the Ophthalmoscopic appearance of the Retina in Pernicious Anaemia, as shown in Figure 31.

A transverse section of a small section of the retina is shown. The haemorrhages, especially those in the anterior layers of the retina, are stained a bright red with eosin. These are specially noticeable around the retinal vessel V. There is also a small haemorrhage in the outer recticular layer.

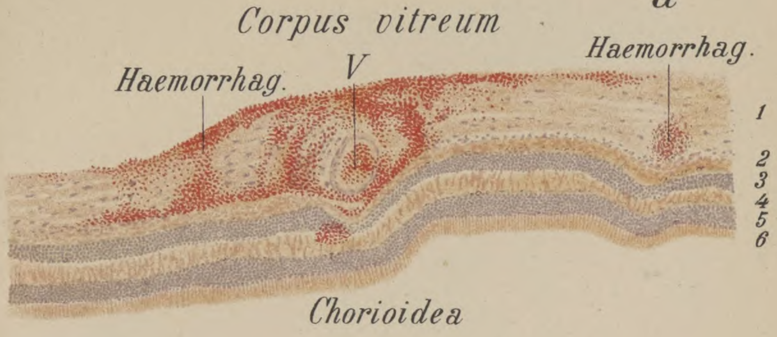
Magnification 90 times.

Figure 67 b. Small Inflammatory Focus in Disseminated Choroiditis. Superficial View.

The choroidal vessels are not seen here, as in Figure 70. On the other hand, on account of the high magnification, the variegated shapes of the pigment cells of the choroid and the cell nuclei, which compose the exudate, can be clearly seen. The drawing was made from a thin longitudinal section of the choroid.

Magnification 112 times.

a


Corpus vitreum
Haemorrhag.
V
Haemorrhag.
1
2
3
4
5
6
Chorioidea

b

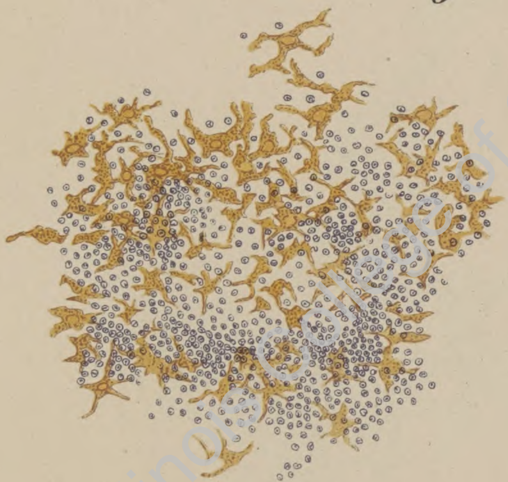


Fig. 67.

Fig. 68.

Diseases of the Choroid.

Figure 68. Recent Disseminated Choroiditis.
(Choroiditis Disseminata).

Inflammatory spots in the choroidal tissue are chiefly remarkable for the fact that the retinal vessels cross them without interruption. When first noticed, these spots are either yellow-white or grey-white patches of irregular shape. Soon, however, the appearance is altered by pigmentary changes, and the edges of the spots become dark, or the centre of the spot itself becomes darker. A varying number of irregularly shaped pigment markings may also be seen adjoining the brighter coloured spots. In the case here illustrated, we have a typical appearance where the areas of choroidal inflammation are roundish in outline. These may run into one another and so form more oblong or irregular shaped patches. All these spots are of recent origin, excepting a few at the upper edge of the picture, where a darkish fringe is already apparent. The more recent patches are more blurred in outline, and yellowish-grey or yellowish-red in colour. The nasal half of the disc is rather reddened and the retinal veins seem fuller than normal. As a general rule, inflammatory areas of the type shown, tend to change into white spots, on account of atrophy of the choroid, which permits of the sclera becoming visible. Generally, the proliferation of the pigment is into the superior layers, as is seen in the upper portions of this picture, and more especially in the succeeding one.

The inflammation is the result of an accumulation of round cells, the surface appearance of which can be seen in Figures 67 b and 70, and a sectional view is shown in Figure 79 a. In this latter Figure, there can also be seen the consequent anatomical changes following this type of inflammation.

Figure 69. Advanced Stage of Disseminated Choroiditis. (Choroiditis Disseminata).

This particular case was of several years' standing, both eyes being affected, and in the earlier stages, the appearance was probably very like that shown in the preceding Figure.

This picture shows extremely well the excessive proliferation of pigment causing the formation of the irregularly shaped patches, often running into each other, and especially crowding the area immediately around the disc. Nearer to the periphery, several of the black patches are edged with a yellowish-red border. Mingled with the black patches, are several yellowish-white or whitish spots of circular shape. These latter appear white on account of choroidal atrophy allowing the sclera to be visible. Where the choroid seems less thickly mottled, the normality of pigmentation and the choroidal vessels is more or less noticeable. The retinal vessels follow their course without any interruption, even in the densely mottled area. From what is known of the microscopical appearances in this disease, it can be conjectured that the retina itself may, in places, be impregnated with pigment migrated from the choroid or from the proliferated pigmented epithelium layer (c.f. Figure 79, where some of the pathological alterations which were met with in this case are shown).

This patient developed later a bad pulmonary phthisis, and only lived for ten years after the completion of this drawing.

Fig. 69.

Fig. 70.

Figure 70. Infiltration Areas (J. J. J1) in the Choroid in Disseminated Choroiditis.

This is a surface view, so that the choroidal vessels (stained yellow) appear as in the ophthalmoscopic picture—but magnified 78 times. Between these vessels is the highly pigmented choroidal stroma (pigmented intervascular spaces). Ordinarily, few cell nuclei can be seen in these areas between the vessels, but in this figure dense accumulations of such nuclei (J. J. J1) can be seen stained a deep violet with hematoxylin. The particular inflammatory area at J1 edged with a straight line, is somewhat obscured to the right, on account of some of the pigmented epithelium layer of the retina adhering to the preparation, which shows that choroidal inflammation might remain unnoticed under such conditions behind this pigmented epithelium, and only be evident on reaching a certain degree of development, or after existing for some time and causing the disappearance of this epithelium. If the pigmentation of the epithelium is light, however—such an area of choroidal inflammation will be seen at an earlier stage with the ophthalmoscope, and appear grey or yellowish-grey. It is also possible for the pigment of the choroid itself to obscure small patches of this kind, so as to render them almost entirely invisible, as is the case in some positions of this particular picture.

Magnification 78 times.

Figure 71. Disseminated Choroiditis in the earlier stages. (Choroiditis Disseminata).

This case differed from the two previously illustrated, by the extreme rapidity of its onset, a large number of the spots appearing simultaneously, the whole of the choroid of one eye alone being affected, in a girl who had no evidence of other disease, but came of a tubercular family. The choroidal patches were remarkable for their rapid increase in size, and had the appearance of markings on a relief map, or as if etched by some caustic fluid. In this type of the disease, the choroid rapidly suffers considerable destruction even in a few weeks. The patches exhibit a dirty grey colour associated with a recent lesion, the bright edges marking the marginal zone spreading in all directions. The intensity of the inflammation is exhibited by the indistinctness of the disc and the adjacent portions of retina, this being partly caused by a slight central opacity in the vitreous, and partly also by the infiltration of inflammatory products into portions of the retina, which is evidenced by the partial obliteration of the retinal vessels.

After suitable treatment for some weeks, the progress was arrested, the grey areas turning black and the paler margins being reduced to pale narrow lines. The inflammation of the disc and adjacent retina disappeared completely.

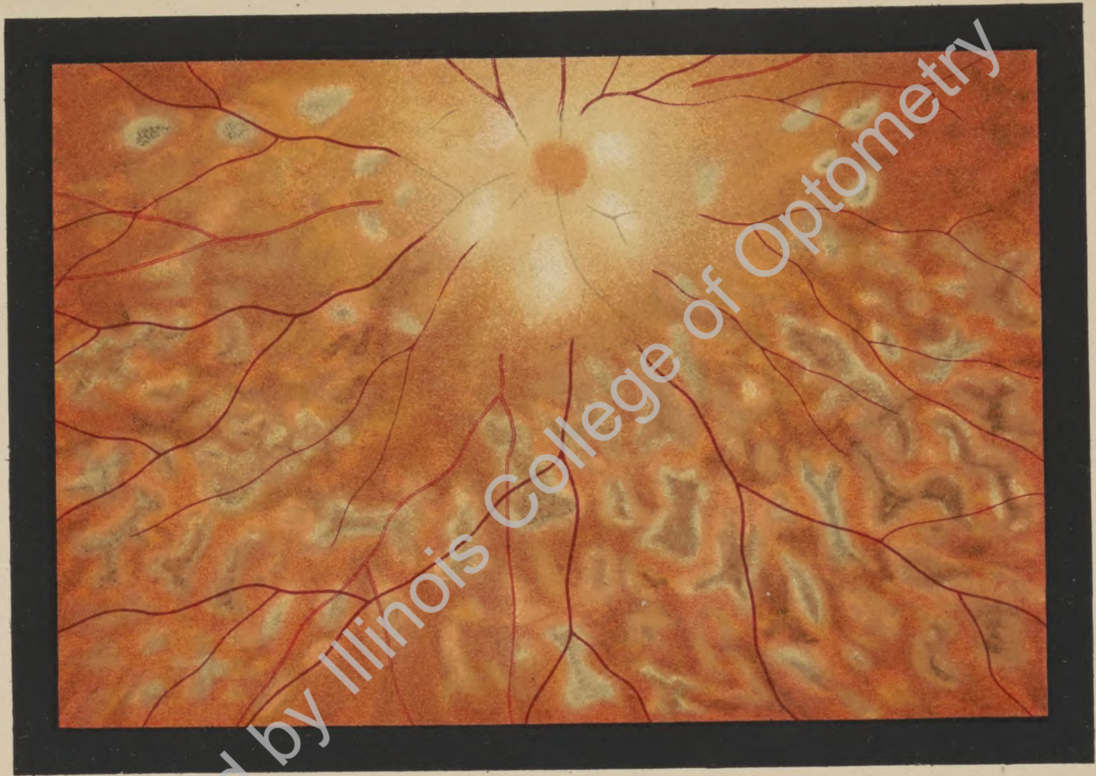


Fig. 71.

Fig. 72.

Figure 72a. Hyaline Bodies (Drusen) of the Vitreous Layer of the Choroid.

A sixty-one year old woman, exhibited the same fundus appearance in her two eyes, although her vision in each was quite normal. These spots are recognised as Drusen of the vitreous layer by their position behind the retinal vessels, their yellowish-white somewhat glistening appearance and their rather circular outline. They are generally seen in the area adjacent to the disc. The anatomical detail of these structures is shown in Figure 82a.

Figure 72b. Senile Pigmentation of the Retina.

The seventy-six year old man, from whom this picture was drawn, like many elderly people, showed pigmentation at the periphery of both fundi, this appearing in the form of fine dots distributed quite irregularly or frequently laid down in lines forming more or less distinct five or six sided figures. This peculiar formation has been observed in similar cases. The perimetric field of this man was quite normal as far as the margins were concerned, but there was some contraction of the colour fields. Night blindness was absent, and there was some diminution in visual acuity on account of commencing cataract. Usually, the acuity can remain quite good in spite of retinal pigmentation, as the central portions of the retina are unaffected.

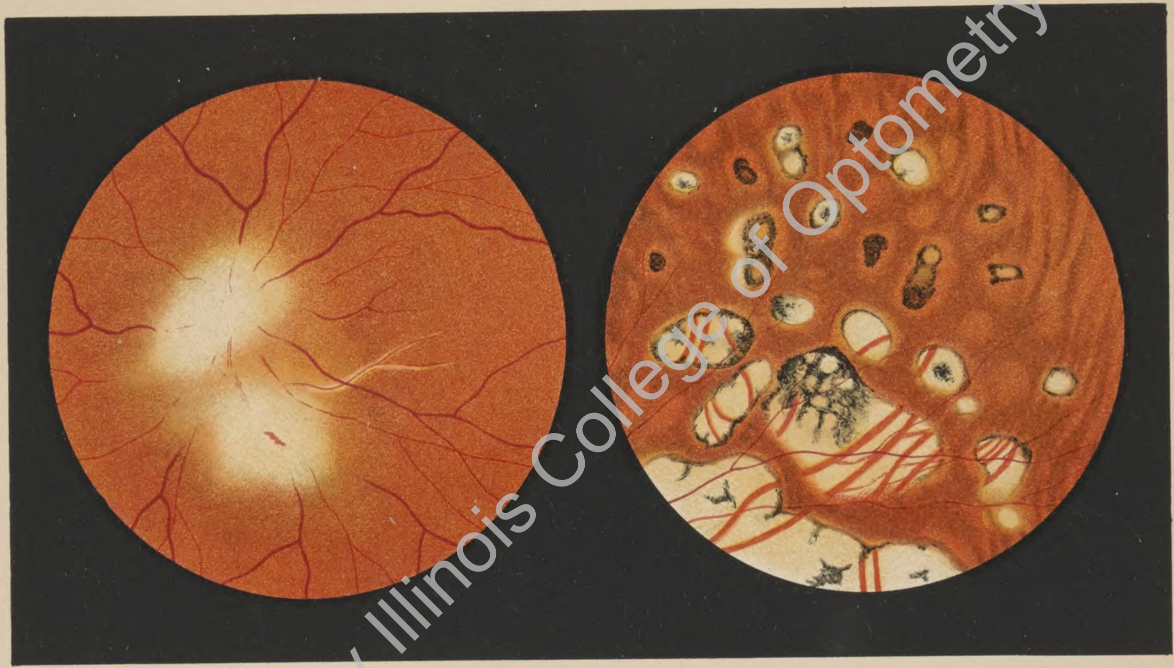
It is not uncommon to find drusen of the vitreous layer associated with this form of retinal disease.

Figure 73a. Recent Disseminated Inflammation of the Choroid, the overlying Retina and of the Optic Disc.

The affection of the retina and the optic disc in conjunction with choroiditis is not very rare (c.f. Figure 71). This inflammation is more acute than that of the usual type of disseminated choroiditis. In the case here illustrated, one affected area was quite close to the optic disc, and about 1·5 mm in diameter (shown in the picture to the left and slightly below the disc), and a second area about twice the size is seen below the disc (actually, of course, above it). In both, the margins are blurred. The overlying portions of retina show quite indistinctly in places, the vessels being obscured, and in the lower of the two areas, there is a small and recent linear hemorrhage, situated centrally. One branch of an artery, running towards the macular region, shows whitish changes in the walls. Atrophy of the choroid developed subsequently, at the position of both the patches (showing as white sharply outlined spots), and there was some atrophy of the optic nerve resembling the cases of neuritis or papillitis already described.

Figure 73b. Disseminated Choroiditis.

This picture shows a fairly typical form of chronic disseminated choroiditis, which manifests itself in many differing forms. The drawing was made from a woman who suffered from the disease for many years, and during its progress the number and size of the inflammatory spots gradually increased. In other respects, her health was quite sound. The white patches are the result of atrophy of the choroid, and here and there, the larger vessels are still intact, and are seen crossing the atrophied areas. The edges of the patches are generally more or less pigmented, indicating that they are of old standing. Some individual patches of pigment are also visible, some edged with a pale border (similar to some shown in Figure 69). The area illustrated in this picture is at the periphery, as is indicated by the retinal vessels.



a Fig. 73. b

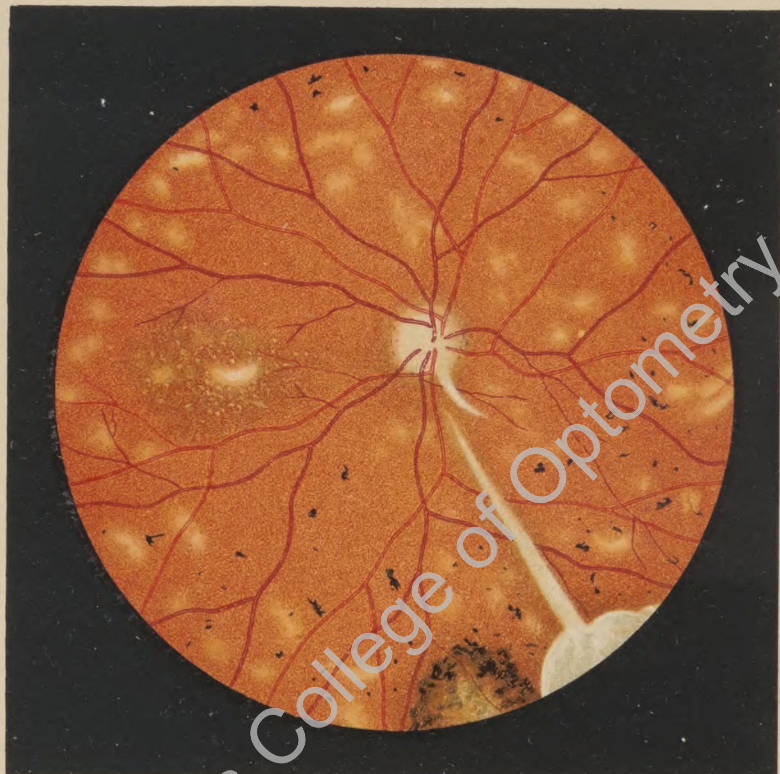


Fig. 74.

Figure 74. Chronic Disseminated Choroiditis with Secondary Pigmentation of the Retina caused by the Presence in the Globe of a particle of a metal cap. (Direct Method).

Whilst pounding metal fuse caps, a tiny particle of copper penetrated the sclera of this child's right eye, close to the inner corneal margin, and became enclosed in a greyish-white hemispherical mass of exudate (similar to the case shown in Figure 60), which projected outwards and downwards in front of the equator into the anterior portion of the vitreous body. In the region of this mass of exudate, a detachment of the retina developed, and later completely subsided. The exudate mass enveloping the particle also became reduced in size. For a considerable time, however, a linear patch of exudate was visible, projecting through the vitreous towards the optic disc. Both the exudate itself, and the linear patch, are visible in the right hand lower quadrant of the picture which was drawn one and a half years after the actual injury. During this period, a number of spots, some yellowish red and some black, appeared over the entire visible fundus, especially in the inner lower quadrant. Immediately after the injury, a slight optic neuritis appeared, and also some macular disease evidenced by a minute speckling (shown in Figure 53b). When the drawing was made, the disc was normal again, but it still exhibited marked changes, especially a marked stippling at the outer margins. The patches of pigment are similar to those seen in pigmentary degeneration of the retina, and probably lie for the most part in the retinal membrane itself. Similar pigmentary degeneration is also illustrated in Figure 46a, which was taken from a similar case.

Figure 75. Miliary Tubercules in the Choroid in Acute Miliary Tuberculosis—an appearance which is often seen in this disease shortly before death. The circular areas, here and there merging one into the other, are blurred in outline, and whilst small and still partly covered by pigmented epithelium, are grey-white in colour, and later become more yellowish-white or yellowish-red. The larger nodules sometimes project forward somewhat forcing the retina outward, causing a corresponding kink to any retinal vessel that may pass across them. Such miliary tubercules are frequently difficult to differentiate from a disseminated choroiditis, such as is shown in Figure 68.

The anatomical details of this choroidal disease are illustrated in the section shown in Figures 82b and 82c.

Fig. 75.

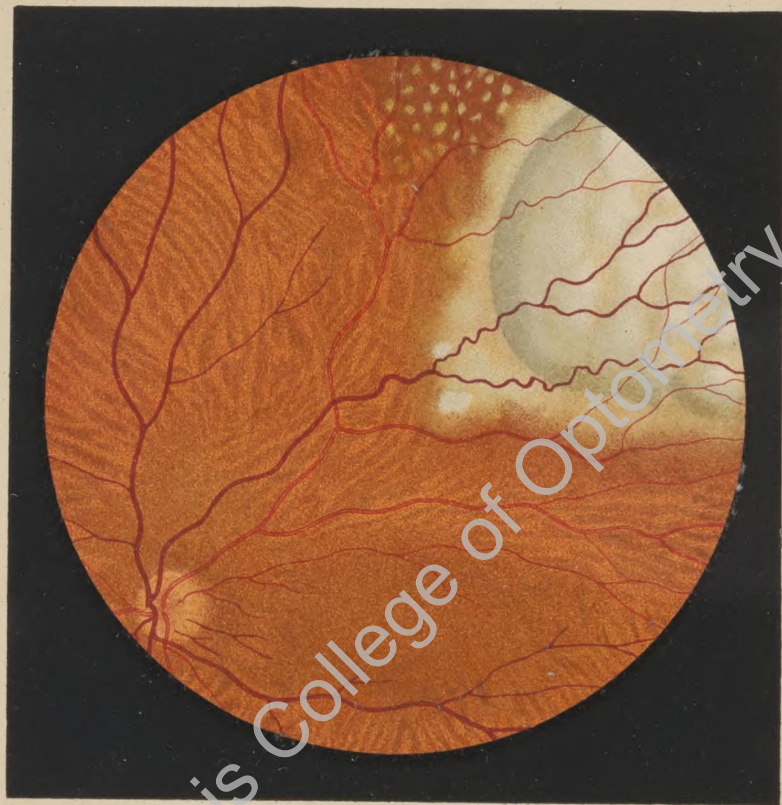


Fig. 76.

Figure 76. Chronic Tuberculosis of the Choroid. (Direct Method).

The tubercular proliferation formed a slowly growing tumour and consisted of a large number of agglomerated tubercle nodules (so called conglobate tubercles), and even with the ophthalmoscope these can be seen to be made up of grey-red nodules. The tumour is near the periphery of the upper right-hand portion, and its anterior edge cannot be seen with the ophthalmoscope but the posterior edge is surrounded by an irregular and badly defined pale bordering of choroid, which is diagnostically of importance. One can deduce from this appearance the existence of some inflammation with corresponding loosening of pigment. In addition, there can be seen near to this border, a number of small disseminated white and yellowish choroidal patches, suggesting that the tumour is causing inflammation in the neighbouring areas, an appearance which is frequently observed in tubercular proliferation (and differentiates it from sarcoma). The disc also seems inflamed, that is to say, reddened and obscured somewhat, this possibly being on account of the boy also having the complication of conglobate tubercules and miliary tuberculosis of the brain. (This particular case was that in which my teacher (Horner) first diagnosed with the ophthalmoscope, tubercle of the choroid in man, and is more fully described, both clinically and anatomically in Graefe's Archiv, Vol. 25).

Figure 77. Sarcoma of the Choroid.

To the left of the picture a roundish tumour, bluish-grey in colour, with a somewhat mottled surface, is seen obscuring one half of the disc, projecting like a great nodule from the equator of the eye into the vitreous body. When examining by means of the direct method, on moving the head to and fro, the observer can see the edge of the tumour clearly, curving over towards the disc, showing that the side of the neoplasm does not actually lie over the disc, but some distance away from it commensurate with the round shape of the growth. The neoplasm is overlaid with retinal tissue, as can be seen by the vessels crossing over its surface. The path of these vessels is rather different from those of a normal retina, being somewhat more tortuous. The sarcomatus nature of the tumour is typified by its darkish colour with a lighter mottling of the whole mass. A simple detachment of the retina would show folds. At the lower edge of the figure such a retinal detachment can be seen, and often occurs with tumours of this type, the rest of the fundus being quite normal.

In Figure 83, the anatomical appearances of this important type of tumour are exhibited.

The differentiated diagnosis of this form of tumour should be carefully considered, especially in contrast with chronic tubercular proliferation (ref. to the description of Figure 76), and Glioma of the Retina. This latter type of tumour is rarely seen with an ophthalmoscope (Ref. Figure 66). It lacks pigmentation and shows many surface hemorrhages. It is found only in children, whilst a sarcoma, on the other hand, is rarely seen before the twelfth year.

Sometimes a form of external tumour, pressing inwards, (and showing some pigmentation) may be mistaken for a sarcoma of the choroid, when the external pressure on the outer wall of the globe, causes internal bulging without any actual perforation. This has been observed in the anterior half of the orbit in two cases of the carcinoma, the actual seats of origin of the growth being in the upper jaw and the post nasal cavity.

It is necessary to differentiate also between actual sarcoma and so-called "phantom tumours." After cataract operations or iridectomy, aqueous escapes through the roots of the iris and flows over the choroid (Fuchs), and after a short time, the resulting cysts bunch forward, projecting into the vitreous; (they may even make their appearance spontaneously in that body).

Fig. 77.

Fig. 78.

Figure 78. Sarcoma of the Choroid.

The pigmented growth in this instance is of much larger size than in the preceding case. The posterior edge of this roundish tumour nearest to the optic disc is not clearly defined, because of some overhang. The retinal vessels, therefore, lose some of their continuity, reappearing later on the surface of the growth, showing some irregularity in their path.

Figure 79a. Recent Disseminated Choroiditis.

The patches of infiltration (J. J.) are here seen in section, and not as in Figures 67b and 70, where the view is from above. They lie between, and in some cases, in front of the vessels, which are also seen in section and containing blood.

Figure 79b.

A later stage of the disease, where the retina also is involved, since it has obviously undergone some degeneration whenever in contact with the choroidal patches. In places, the retina is reduced to a mere membrane of connective tissue, into which the pigment from the pigmented epithelium layer is beginning to infuse. This latter is proliferating, some of the cells having given up their pigment, and in other places the epithelium itself is absent. Just below the retina, through the entire section, the vitreous layer of the choroid (L.V.) can be traced. In the choroid itself can be noticed some vessels filled with blood, in both cross and longitudinal section, the increase in connective and scar tissue is, however, indicated by some lack of both vessels and pigment in certain places.

At J, an inflammatory irritation has built up a fresh area of infiltration. In certain places, the retina and the choroid appear to be adhering to each other ; the hollow spaces between these points of adhesion, were at one time packed with pigment and exudate, but these contents have largely disappeared during the preparation of the section.

Figure 79c.

No recent inflammatory infiltrations are to be seen in this section, but there are adhesions between retina and choroid ; both are thinned, and reduced to scar tissue. The pigmented epithelium shows marked proliferation, and protrudes into the retina in places (secondary pigmentation of the retina—Ref. Fig. 43). In other places, there is an entire absence of pigmented epithelium. The choroidal vessels have almost entirely disappeared, and pigment appears to be sparse. Wherever both pigment and the overlying pigmented epithelium are absent (as, for example, on the extreme left of the figure), the sclera will shine through in the ophthalmoscopic picture, thus producing the white patches, typical of disseminated choroiditis. Accumulations of pigment, as at P, will form the black spots seen with the ophthalmoscope.

The magnification of all three Figures is 78 times.

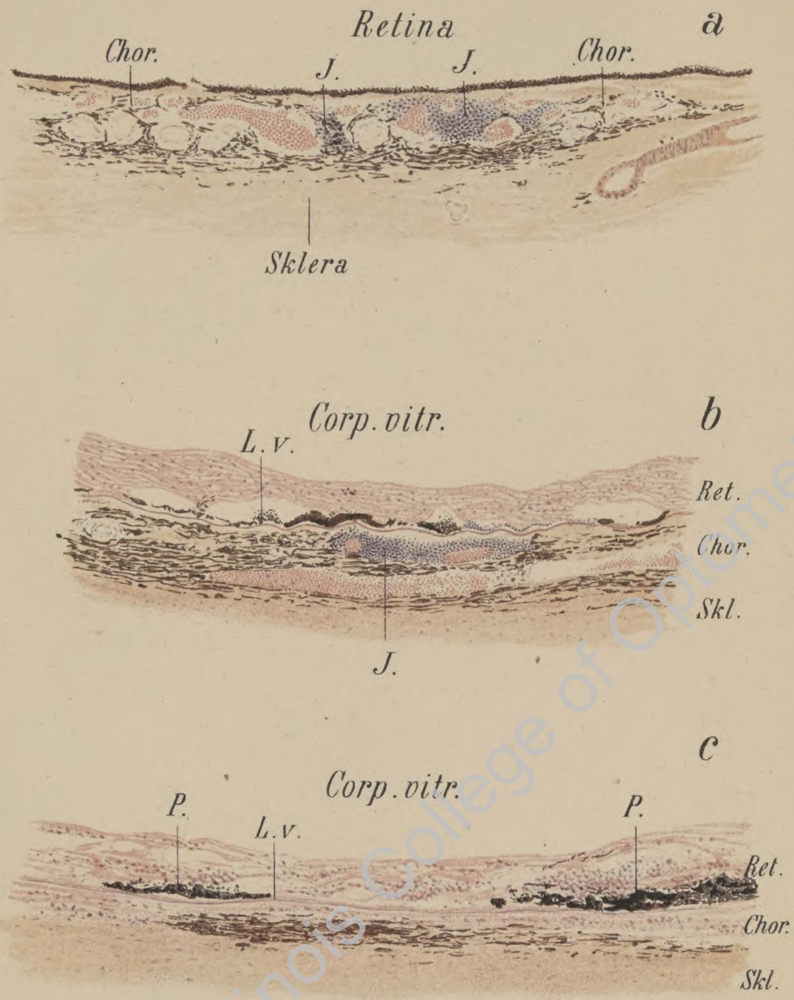

Retina
a
Chor.
J.
J.
Chor.
Sklera
Corp. vitr.
b
L. v.
Ret.
Chor.
Skl.
J.
c
Corp. vitr.
P.
L. v.
P.
Ret.
Chor.
Skl.

Fig. 79.

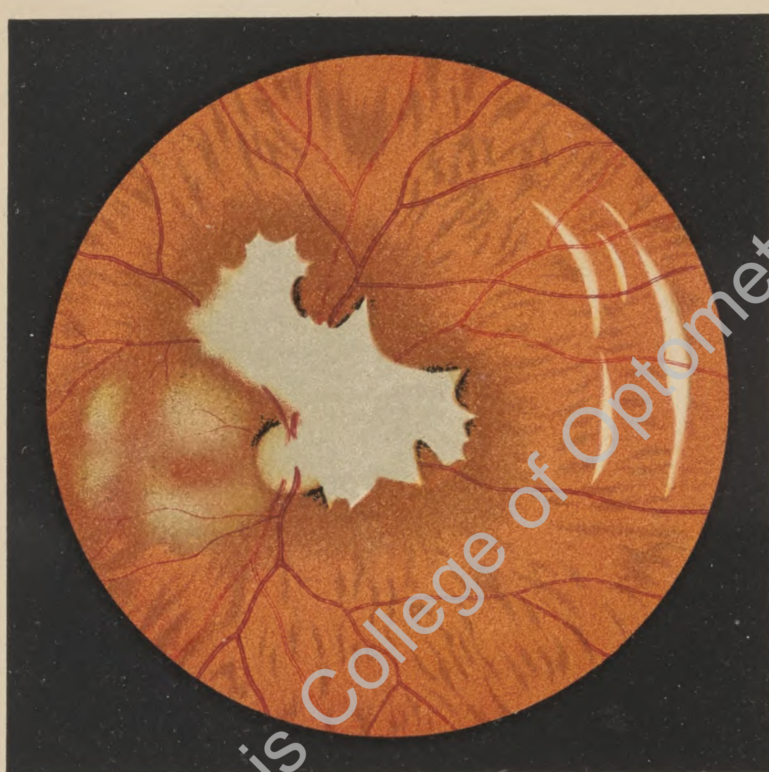


Fig. 80.

Figure 80. Changes in the Choroid, due to violent contusion of the eye. Lacerations of the Choroid.

The paper packing of a blank cartridge had caused a severe contusion of this eye. After the blood, which suffused the anterior chamber and the vitreous body, had disappeared, a whitish membrane, consisting, apparently, of connective tissue, covered a considerable area on the nasal and lower sides of the disc, and one half of the nerve itself, the retinal vessels, as well as part of the disc, being quite obscured, as is seen in the picture. The margins of this membrane, showed a series of arc-shaped curves in places, somewhat edged with black. Further out, on the nasal side, can be seen five large and small linear lacerations in the choroid, characteristically arranged in concentric curves, parallel to the equator, their white appearance being accounted for by the fact that the sclera shines through the rents in the choroidal structure. Their outline is sharply defined, and at times faintly edged with black. The retinal vessels pass undisturbed across the lacerations. Between the disc and the macula, a fine stippling is noticeable. The rest of the fundus appears quite normal.

Figure 81. Sclerosis of the Choroidal Vessels, Disseminated Choroiditis and Secondary Pigmentation of the Retina.

This picture was drawn from a very strongly marked case, yet frequently, one can see, in this disease, rather less pronounced alterations, where the appearance is limited to a much smaller area in the fundus. The typical features of the disease are very well shown in this case, in the sclerosis of the choroidal vessels and the atrophy of the retinal pigment, so that the choroid is clearly visible, and the choroidal vessels, whose walls have become white and opaque, show up white against a dark background, instead of their usual red appearance. This appearance of the vessels is most marked at the posterior pole of the globe, around the disc area, and gradually diminished towards the periphery. At the margins of the area of greatest arterial sclerosis, there are a few white atrophied patches in the choroid, some with pigmented edges. In the same zone, can also be seen some jagged pigment patches, which lie well in the retina. The retina itself is not diseased, and the retinal vessels display no changes in their walls.

Wangemann's experimental researches prove that obstructions to the nutrition of the choroid invariably cause atrophy and secondary pigmentation of the retina.

Fig. 81.

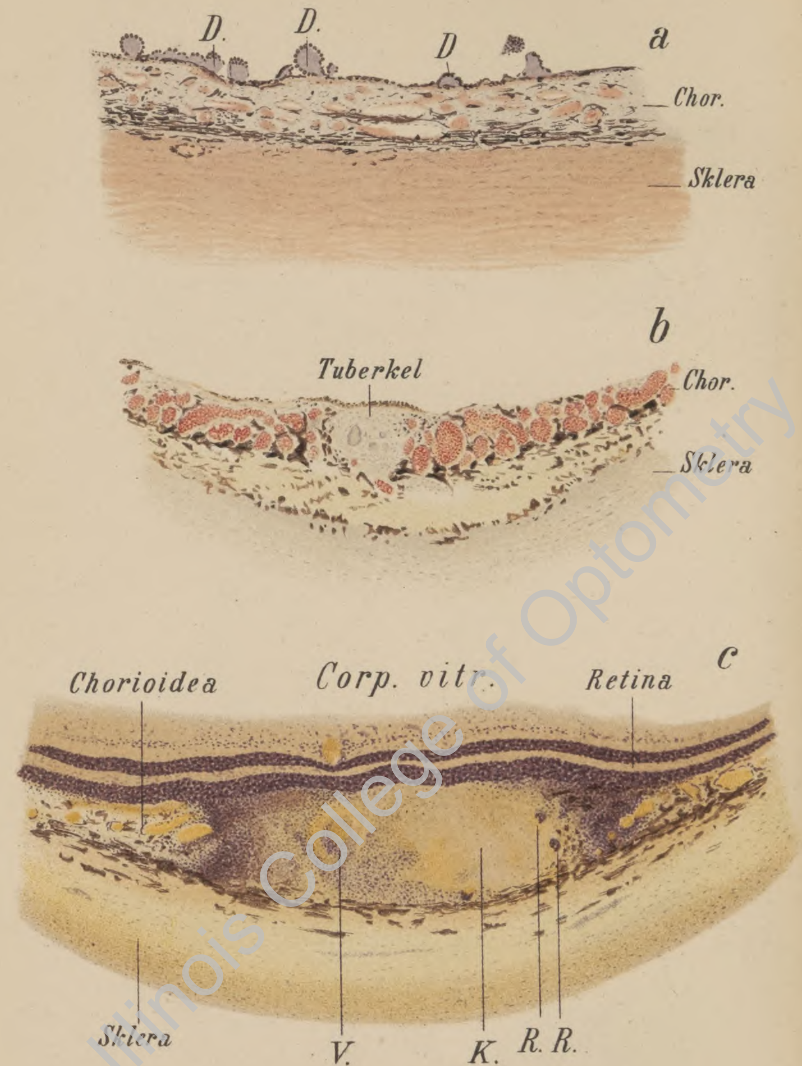

D.
D.
D
a
Chor.
Sklera
b
Tuberkel
Chor.
Sklera
c
Chorioidea
Corp. vitr.
Retina
Sklera
V.
K.
R. R.

Fig. 82.

Figure 82a. Hyaline Bodies (Drusen) of the Vitreous Layer.

(Ref. Figure 72a).

The hyaline bodies are seen, stained violet with hematoxylin, lying upon the vitreous layer and generally surrounded with pigmented epithelium cells. The choroid is normal and the retina in this particular case became detached, and is, therefore, not shown in the picture.

Figure 82b. Miliary Tubercle of the Choroid.

(Ref. Figure 75).

The specimen being a section near to the equator, and parallel to it, the choroidal vessels are seen almost invariably in cross section. At the centre of the tubercle can be seen some giant cells. The retina is not shown in the drawing. Between choroid and sclera, a gap was formed during preparation, and this has been partly filled with suprachoroidal layers. The patient subsequently died of miliary tuberculosis.

Figure 82c. Large Tubercular Growth in the Choroid consisting of several Nodules.

V. Cross section of a choroidal vessel; K, caseous part of the tubercle; R.R., giant cells.

Magnification of all three Figures, 30 times.

Figure 83. Meridional Sections through Eyes with Choroidal Sarcoma, stained with hematoxylin. and eosin (life size).

In Figure " a " between the retina and the tumour, there is a layer of amorphous exudate, similar to that which is beneath the detached portion of the retina.

In Figure " b " the tumour is covered with retina, except on its posterior portion, and in Figure " c " the retina is covering the entire surface of the tumour

In none of these three cases, did the tumour actually break through the sclera.

In Figure " d " the microscopical structure of a pigmented sarcoma of the choroid is depicted, evidently made up chiefly of spindle shaped cells, more or less charged with pigment, though in some places this is entirely absent.

Magnification : 112 times.

Fig. 83.

a

b

c

d

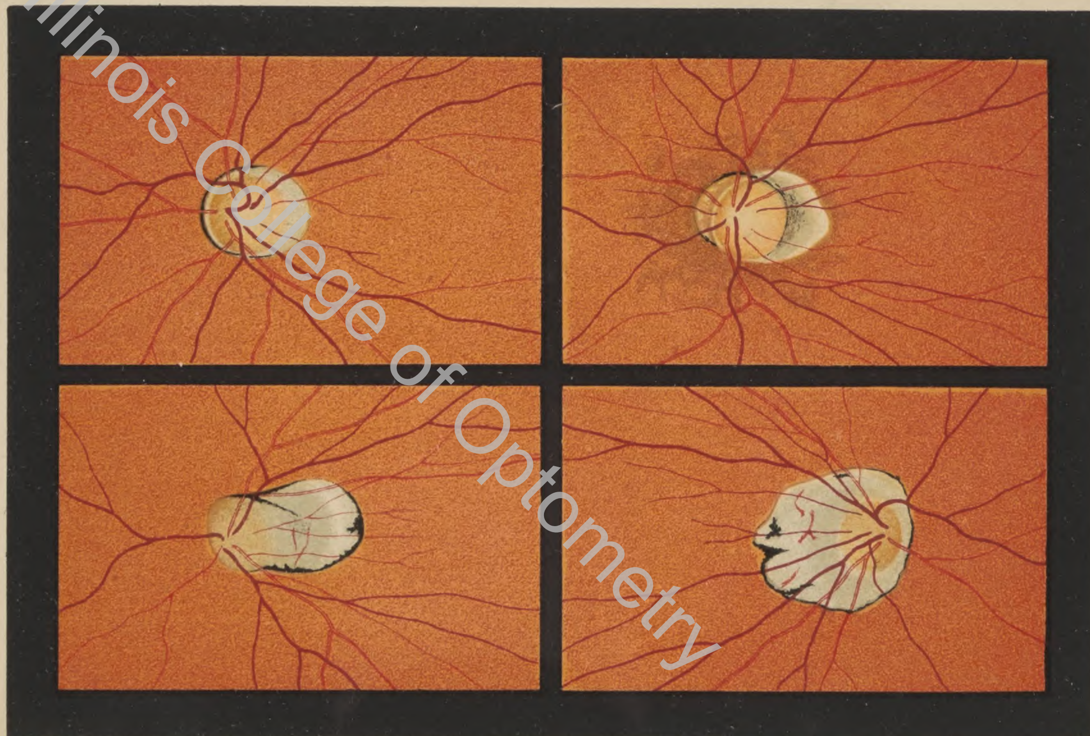


Fig. 84.

Figure 84. Atrophy of the Choroid near to the Optic Disc in cases of Myopia.

These four pictures (just as the two succeeding ones and the five shown in Figures 44 and 45) represent cases of choroidal atrophy near to the optic nerve, which can be seen in varying forms, sometimes in the shape of a sickle or half-moon, or even in the forms of a cone or meniscus, and is usually first noticed, and seems most pronounced, at the temporal edge of the disc. When this atrophy is present, the sclera is clearly visible, as a more or less whitish patch, and showing up by contrast any few pigment remnants and remaining vessels, as in Fig. 84d. The retinal vessels pass without interruption over the atrophied areas, showing no kinks as they cross the peripheral edges of the whitish patches. It is not, therefore, correct to regard such atrophic patches as staphylomata. It is only when there is visible kinking of retinal vessels and when such kinking actually corresponds to the edge of the retinal depression that we can regard it as a true staphyloma (such as is shown in Figure 85.) In the four pictures here exhibited, as well as in the others already mentioned as similar to them, the retinal vessels seem rather straighter than normal and more numerous in the temporal half. This is often the case in high degrees of myopia. Stilling and others suggest that the appearance of small sickles or menisci, is owing to these corresponding to the lateral wall of the scleral canal through which the optic nerve enters the eye.

Figure 85. True Staphyloma in a highly Myopic Eye.
(First described by Weiss).

Neither the pale sickle nor meniscus shaped patches of atrophy at the temporal edge of the disc, or even the circular patch of choroidal atrophy around the disc practically ever show any staphylomatous bulging even when moderately large, and very rarely even when they are extremely large. They, therefore, do not merit the use of this name, but in the case of a true staphyloma, such as is shown in this Figure, the use of the term is justified. Such cases are usually associated only with very high grades of myopia (20D and over), and are not, therefore, common.

In this case, there can be seen, particularly on the nasal side of the disc, the clear cut edge of an excavation, and the blood vessels when passing over it are distinctly deflected. The margin of the excavation is evidenced either by a more or less definite shadow or by the distinct grey line along the summit of the curve. This curve may vary considerably in size, forming either a greater or a smaller segment of a circle or oval. In some cases, the edge of the staphyloma is circular and surrounding completely the posterior pole of the globe—but even then, will appear more pronounced on the nasal side of the disc. "Parallactic displacement" enables us to see the edge of a staphyloma, even when it seems to be difficult with the ophthalmoscope.

In this particular illustration, there can be seen also three sickle-shaped patches of atrophy near the disc, over which the vessels pass without apparent interruption. It is also noticeable that the path of the retinal vessels is typical of high myopia, the main trunks extending more to the temporal half rather than passing more directly upwards and downwards. Those on the nasal side appear to be projected forward especially as they pass over the edge of the staphyloma. There is a diminution and some loosening of the pigmentation at the posterior pole, (the macular area and immediately surrounding it), which is also indicative of high myopia. In this particular patient, the myopia of 30 D was neutralised by an operation (removal of the lens), so that the eye became almost emmetropic with good visual acuity.

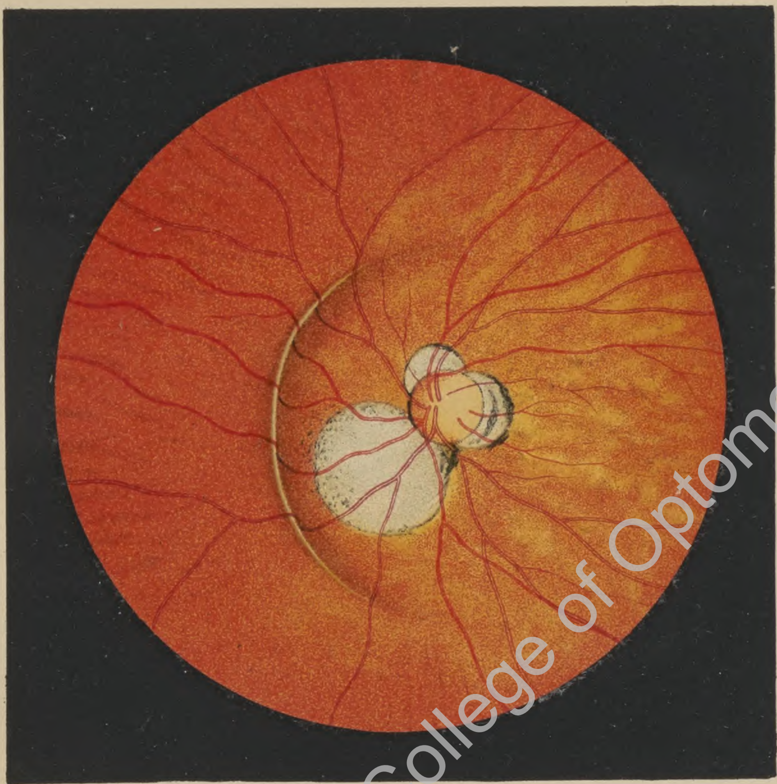


Fig. 85.

a

b

Fig. 86.

Figure 86. Posterior Venae Vorticosae.

Whilst in normal eyes, the principal exit from the choroid of the venous blood is through the so-called venae vorticosae at the equator of the globe (see Figure 10b), in very myopic eyes with sparse pigmentation in the neighbourhood of the disc, one can often see venous trunks conveying blood from the choroid to the posterior portion of the globe. The main trunks of these venous vessels are more or less large, and disappear quite near to the optic disc, or at a very short distance away from it. They often exhibit a number of ramifications and seem so tortuous in the neighbourhood of the disc, that they look extremely like the real venae vorticosae.

That these vessels, (of which little has been said up to the present) really are veins is shown by the fact that by lightly pressing on the globe at their central extremities, they empty, just as do the retinal veins.

In badly pigmented eyes and in albinos, these vessels do not occur except when myopia is present; it can be assumed that there is some connection between them and short-sightedness, though the reason is not clearly understood.

The pictures shown in Figure 86 were drawn from two women, one of whom had her myopia of twenty dioptres neutralised by operation. In Figure 86a, five of these choroidal veins can be seen, varying somewhat in the number of their branches, and all disappearing at the edge of the disc. In Figure 86b, there are three, one of which unites a large number of subsidiary branches coming from above.

Figure 87. The Pupillometer.

When comparing two eyes, it is possible to estimate to within a few millimetres any differences in pupilliary diameters. A more precise way, in daily practice, of correctly measuring the width of a pupil, would be to actually compare it with painted pictures of the pupil of known sizes. The one corresponding to the pupil can be easily selected, if a number of such pictures of varying diameters are arranged in a row. That this method is sufficiently accurate for general purposes, I have proved in my own experience.

One of these rows of pupil spots can be cut from the page opposite and mounted on the millimetre rule used for inter-pupilliary measurement when fitting for spectacles—or on to a separate strip of cardboard. The other two will serve for renewals.